

Earth's Ozone Layer: Science at the Crossroads

AIR & SPACE

Smithsonian • November 1994

The Stearman

It trained a generation

The
New
Missile
Gap



\$3.⁵⁰ U.S./\$4.⁵⁰ Canada

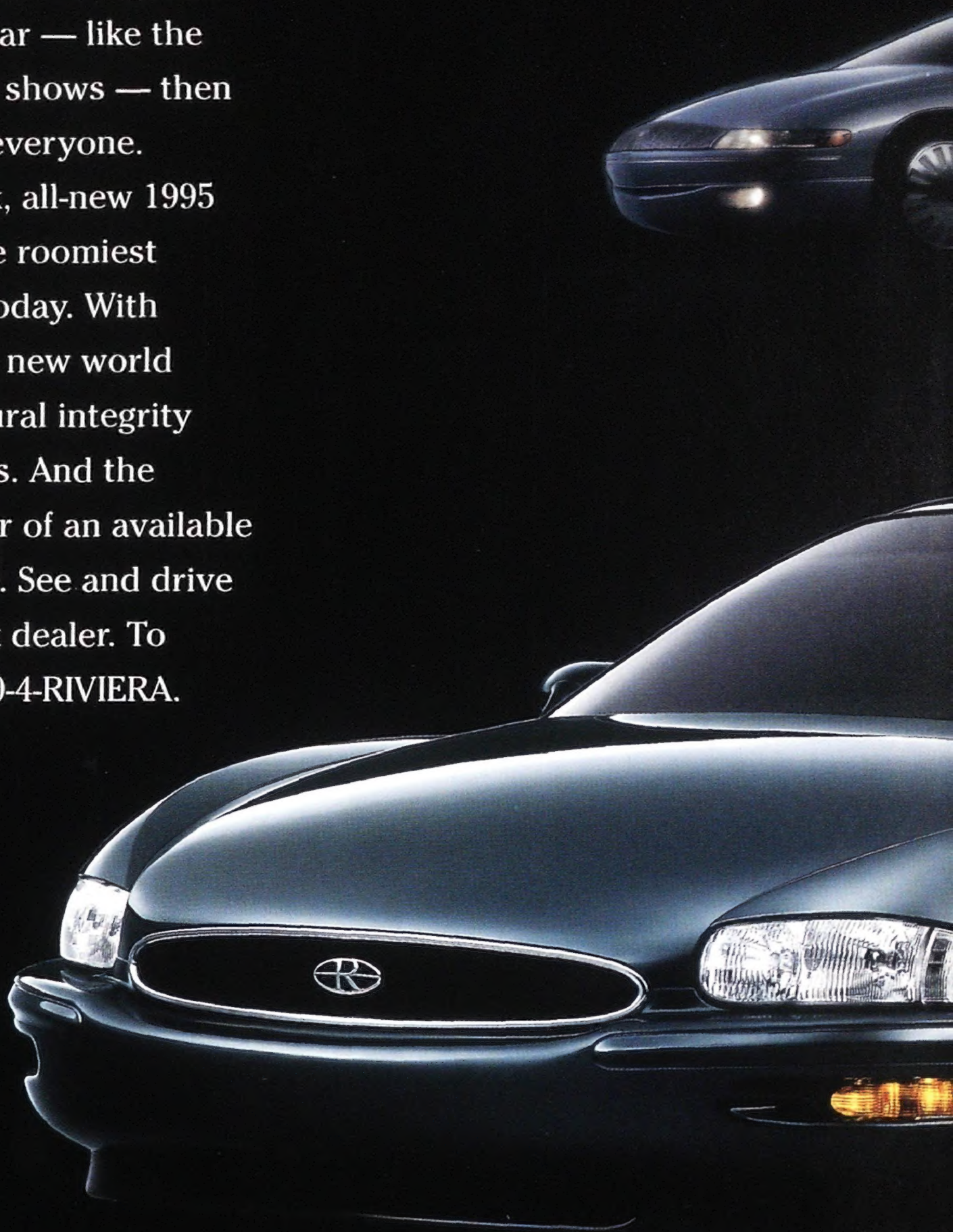


Finally, a concept car... comes to life.

The concept is simple: Design an innovative concept car — like the ones you see at auto shows — then make it available to everyone. Introducing the sleek, all-new 1995 Riviera by Buick. The roomiest coupe in the world today. With a body unit that sets new world standards for structural integrity among luxury coupes. And the highly efficient power of an available supercharged engine. See and drive Riviera at your Buick dealer. To learn more, call 1-800-4-RIVIERA.



Riviera by Buick



©1994 GM Corp. All rights reserved.
Riviera is a registered trademark of GM Corp.
Buckle up, America!



AIR & SPACE

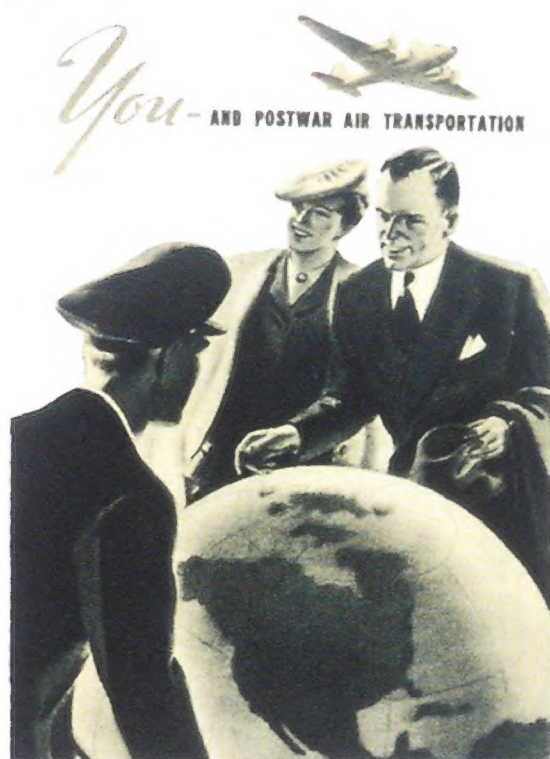
Smithsonian



Special Graphic Supplement: EARTH'S DEFENSIVE SHIELD

Without the sun, there
would be no life on Earth.
But too much of a good
thing would be deadly.

82



Cover:
Photographer Chad
Slattery took his
camera aloft to
photograph a
Stearman from
Santa Monica's
Museum of Flying.

AIR & SPACE/Smithsonian (ISSN 0886-2257) is published bimonthly by the Smithsonian Institution, 900 Jefferson Drive, Washington, DC 20560. ©Smithsonian Institution, 1994. All rights reserved. Reproduction in whole or in part without permission is prohibited. Editorial offices are at 370 L'Enfant Promenade SW, 10th

Floor, Washington, D.C. 20024. Advertising and circulation offices are at 420 Lexington Ave., New York, NY 10170. SUBSCRIPTION PRICES: United States and possessions: \$18 a year. Canada and all other countries add \$6.00 for each year. Eighty-five percent of dues is designated for magazine subscription. Current issue

price is \$3.50. Back issue price is \$5.00. MAILING LISTS: From time to time we make our subscriber list available to companies that sell goods and services by mail that we believe would interest our readers. If you would rather not receive such mailings, please send your current mailing label or exact copy to: AIR &

SPACE/Smithsonian, Mail Preference Service, PO Box 55593, Boulder, CO 80322-5593. SUBSCRIPTION SERVICE: Should you wish to change your address or order new subscriptions, you can do so by writing AIR & SPACE/Smithsonian, PO Box 53261, Boulder, CO 80322-3261, or by calling 1-800-766-2149.

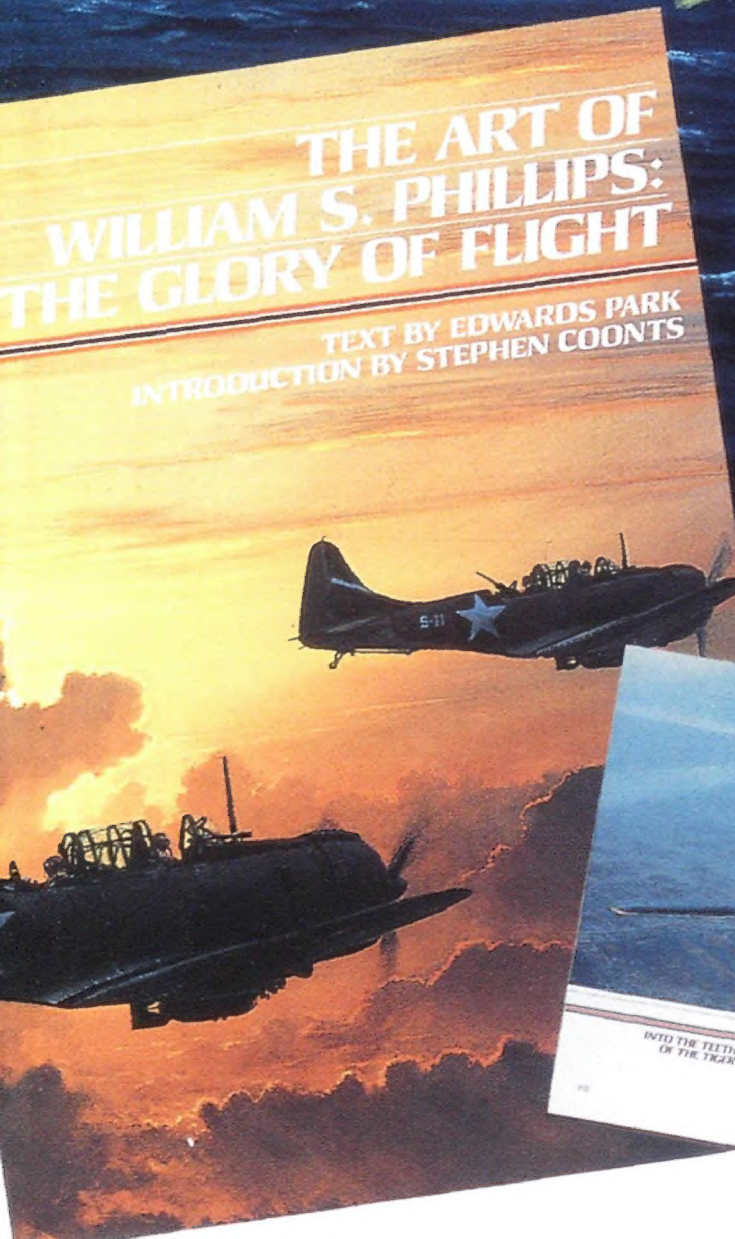
CONTENTS

- 28 **Ozone Forecast: Partly Cloudy** by Carl A. Posey
Illustrations by Jan Adkins
A close look at what we know about the ozone layer—and what we don't know.
- 40 **Back to the Basics** by Bill Marsano
Photographs by Eric Lars Bakke
Aviators-in-training knew the Stearman by several names. Not all of them were polite.
- 52 **Bear Arms** by Bill Sweetman
In the international arms bazaar, the Russians are peddling some pretty hot items.
- 62 **A Trip to the Moon** by Frank H. Winter and Randy Liebermann
Ah, the good old days, when a ticket for a lunar voyage cost only 50 cents.
- Reflections on the Cold War:**
Second in a Series
- 68 **LIFE IN THE EGG** by Michael R. Boldrick
Illustrations by Paul DiMare
When you pull 24-hour duty overseeing nuclear missiles, you have plenty of time to wonder: Would I really do it?
- 74 **The Cyberspace Program** by Tony Reichhardt
Illustrations by David Peters
How to explore the cosmos from the comfort of a computer terminal.
- 82 **The Skies, the Limits** by Henry Scammell
Fifty years ago 54 nations met in Chicago to determine the future of international air travel.



Departments

- | | | | |
|----|-----------------|-----|----------------------------|
| 4 | Viewport | 39 | The Smithsonian Traveler |
| 6 | Letters | 92 | Reviews & Previews |
| 12 | Soundings | 97 | Calendar |
| 20 | In the Museum | 98 | Credits |
| 24 | Above & Beyond | 99 | "The Satellite Sky" Update |
| 26 | Flights & Fancy | 99 | Forecast |
| | | 100 | Collections |



EXPERIENCE THE GLORY OF FLIGHT



Fasten your seat belt and prepare for takeoff with *The Art of William S. Phillips: The Glory of Flight*. At last, you can take to the sky with America's premier aviation artist in the first book of his collected works ever published.

Accompanying Phillips' moving paintings is Edwards Park's "from the cockpit" narrative. Former fighter pilot and *Air & Space* editor, Park takes us on a flight we are not soon to forget.

For more information or to order your copy of *The Art of William S. Phillips: The Glory of Flight*, **CALL TOLL-FREE 1-800-868-4512** or mail in the order form on the right.

YES! Send me ____ copies of *The Art of William S. Phillips: The Glory of Flight* at \$60.00 each, plus \$6.00 shipping and handling. (Add \$4.00 for each additional book.) Virginia residents add 4.5% sales tax.

____ Visa ____ MasterCard ____ American Express Exp. Date ____

Credit Card Number ____

Name ____

Address ____

City ____ State ____ Zip ____

Daytime Phone Number ____

MAIL TO: Howell Press, 1147 River Road, Suite 2, Charlottesville, VA 22901
or CALL TOLL-FREE 1-800-868-4512

Secretary of the Smithsonian Institution
I. Michael Heyman

Editor
George C. Larson

Managing Editor
Tom Huntington

Senior Editor
Linda Musser Shiner

Departments Editor
Patricia Trenner

Senior Associate Editor
Perry Turner

Associate Editors
Karen Jensen
David Savold
Diane Tedeschi

Photography/Illustration
Caroline Sheen

Art Director
Phil Jordan
Gretchen Lessing

Publisher
Ronald C. Walker

Administration
Carey O. Randall, Associate Publisher

Advertising
Louis C. Kolenda, Director

Circulation
Liberta Abbondante, Director
Gale Page, Assistant Director
Caroline Topak, Marketing Director
Elizabeth Hopkins, Planning Director

Production
Sarah D. Kingsley, Manager
Carrie H. Wiklund

Business
Shelia Perry Brannum, Manager

Founder
Walter J. Boyne

Publisher Emeritus
Joseph J. Bonsignore

A Passion for History

Among the eight million visitors to the National Air and Space Museum each year, only a few thousand may be aware of the Smithsonian History of Aviation series. Von D. Hardesty, curator of aeronautics at the Museum, is the series editor. In collaboration with Felix Lowe of the Smithsonian Institution Press, he seeks out the finest new manuscripts, selects the most interesting classics for reprinting, and occasionally throws in a particularly striking proceedings volume.

The series has succeeded beyond our expectations. We have produced biographies, like Richard G. Davis' *Carl A. Spaatz and the Air War in Europe*, Peter Jakab's *Visions of a Flying Machine*, and Robert Rummel's *Howard Hughes and TWA*; business histories, like Henry Cord Meyer's *Airshipmen, Businessmen, and Politics, 1890-1940*; social and cultural volumes, such as Stanley Sandler's *Segregated Skies*; and military histories, exemplified by John H. Morrow Jr.'s *The Great War in the Air: Military Aviation from 1909 to 1921* and *Carrier Warfare in the Pacific: An Oral History Collection* edited by E.T. Wooldridge. Wooldridge and Jakab are also curators at the Museum.

But this is just a small part of the Museum's contribution to the history of aviation. Our curators have also written a wide range of books published with other presses. Among these is Tom Crouch's biography of the Wright brothers, *The Bishop's Boys*; Dominick Pisano's recent study, *To Fill the Skies with Pilots: The Civilian Pilot Training Program, 1939-46*; R.E.G. Davies' many books on airlines, like Pan Am, Aeroflot, Lufthansa, and Delta; and Robert van der Linden's *The Boeing 247: The First Modern Airliner*. Many of these are prize-winning volumes.

Part of a truly outstanding historian's training is a scrupulous regard for evidence. Whereas a great deal of aviation lore has come down to us in anecdotal form, good scholarship distinguishes between fanciful tales and events that can be thoroughly documented. In the process, for better or worse, many

colorful incidents are found never to have taken place—though they would have been fun if they had. More seriously, pieces of evidence supporting long-cherished views may be found to be ambiguous, spurious, or non-existent—a painful experience for those who are bewildered by the sudden loss of factual support for a cause in which they strongly believe.

When personal experience tells us one thing and a historian's archival research shows something else altogether, our first impulse is to doubt the historian's research. But if the facts can't be shaken and their selection has been balanced and unbiased, we may have to admit that, though our convictions may be shaken, the historian has set the record straight. That's his or her job. It may be inconvenient, it may undermine an agenda we are pushing, but it needs to be respected.

Aviation is full of wonderful stories that color our entire attitude toward flight. The curators on the Museum's staff, who prepare our exhibitions and select and care for our collections, by and large are also the historians doing the research and writing the kind of books mentioned above. Their job is to lift the veneer and look beneath it. They may discover sturdy oak or soft pine, but historians have to report their findings accurately. Frequently they find evidence debunking passionately defended credos. Loyal friends may then feel betrayed, and accusations of political correctness or revisionism may be traded.

History does arouse passions. But when historians strive for truth, their new finds can be just as interesting and attractive as the stories they displace. To be sure, highly focused agendas may, for a while, suffer setbacks, and that may be painful. But on such occasions, we need to remind ourselves of the old adage, simplistic though it may sound, that the truth shall set us free.

—Martin Harwit is the director of the National Air and Space Museum.

Your opportunity to take your place on the bridge of the U.S.S. ENTERPRISE.™



The removable dome permits access to the bridge.



The primary sensor dish is electroplated in 24-karat gold.



The hangar door actually opens to reveal the shuttlecraft Galileo.™

Paramount Pictures Presents
the Official Die-Cast Replica of
the U.S.S. ENTERPRISE.
Authorized and authenticated
by Paramount Pictures.

These are the voyages of the STARSHIP ENTERPRISE.™ Its mission: to bring the greatest adventure of all into your home. Based on the actual plans of the original U.S.S. Enterprise. An incredibly detailed model that would impress even Spock's analytical mind.

Precision-crafted and measuring a full 15" in length. Authentic down to phaser banks on the hull and Kirk's command chair on the bridge. Blazing its way into the future with a primary sensor disk electroplated in 24 karat gold.

STARSHIP ENTERPRISE is ready for transport into your home, with its own custom-display case bearing a handsome commemorative ingot, minted in solid sterling silver. The price, \$295, payable in convenient monthly installments.

SATISFACTION GUARANTEED

If you wish to return any Franklin Mint Precision Models purchase, you may do so within 30 days of your receipt of that purchase for replacement, credit or refund.



Actual size of the Starship Enterprise is 15" (38.10 cm) long.

TM, © & © 1994 Paramount Pictures. All Rights Reserved. STAR TREK and Related Marks are Trademarks of Paramount Pictures.

THE OFFICIAL EDITION OF
**STARSHIP
ENTERPRISE™**



Please mail by November 30, 1994.

Franklin Mint Precision Models
Franklin Center, PA 19091-0001

Please accept my order for the STARSHIP ENTERPRISE.™

I need SEND NO MONEY NOW. I will be billed in 5 equal monthly installments of \$59.* each, with the first payment due prior to shipment.

*Plus my state sales tax and a one-time charge of \$3. for shipping and handling.

SIGNATURE _____

ALL ORDERS ARE SUBJECT TO ACCEPTANCE

MR/MRS/MISS _____

PLEASE PRINT CLEARLY

ADDRESS _____ APT. # _____

CITY _____

STATE _____ ZIP _____

TELEPHONE # (_____) _____

14379-70-001-80DW

Secretary of the Smithsonian Institution
I. Michael Heyman

Director of the National Air and
Space Museum
Dr. Martin Harwit

Board of Regents
Smithsonian Institution

Ex Officio
Chief Justice of the United States
William Rehnquist, Chancellor
Vice President of the United States
Albert Gore Jr.

Appointed by the President
of the Senate
Honorable Daniel P. Moynihan
Honorable James R. Sasser
Honorable John W. Warner

Appointed by the Speaker of the House
Honorable Thomas S. Foley
Honorable Joseph M. McDade
Honorable Norman Y. Mineta

Appointed by Joint Resolution of Congress
Honorable Jeannine Smith Clark
Honorable Barber B. Conable Jr.
Dr. Hanna H. Gray
Dr. Manuel L. Ibáñez
Mr. Samuel C. Johnson
Dr. Homer A. Neal
Mr. Frank A. Shrontz
Mr. Wesley S. Williams Jr.

Contributing Editors, Air & Space/
Smithsonian

Michael Beschloss	Nick Kotz
Roger Bilstein	Saunders B. Kramer
William E. Burrows	W. David Lewis
Eric Chaisson	Stephen Maran
Tom Crouch	Laurence Marschall
David DeVorkin	Ted Maxwell
Ron Dick	Ron Miller
Freeman Dyson	James Oberg
Daniel Ford	Edwards Park
Greg Freiherr	Dominick Pisano
Sylvia D. Fries	Robert E. Pollack
Owen Gingerich	Fred Reed
Donald Goldsmith	George Robinson
Stephen Jay Gould	Theodore Robinson
George Greenstein	Marcia Smith
William Gregory	Robert W. Smith
R. Cargill Hall	Jill Tarter
Richard Hallion	Steven L. Thompson
Jim Hansen	William Triplett
Gregg Herken	Albert Van Helden
Richard H. Kohn	G.L. Verschuur
Nick Komons	Stephan Wilkinson

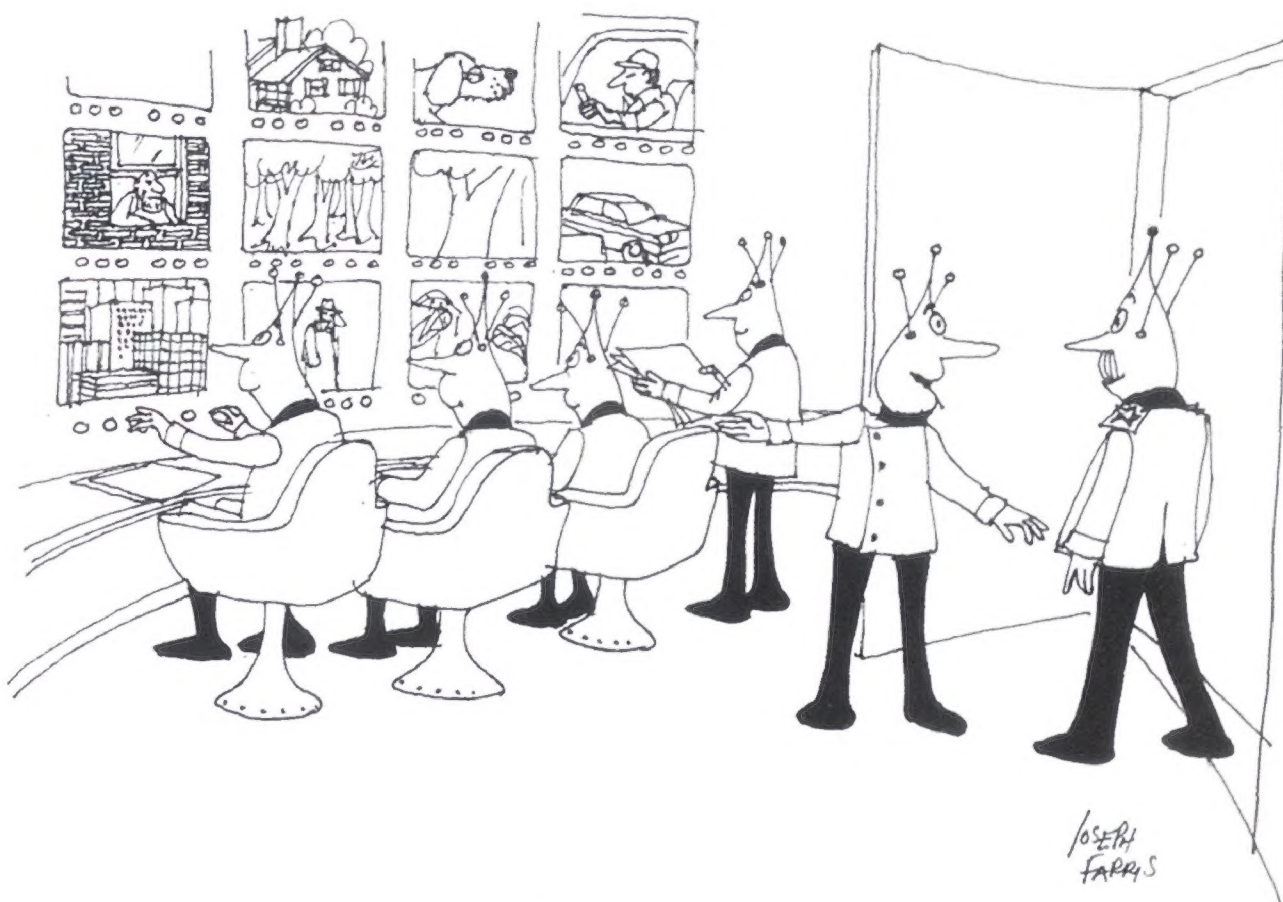
The Enola Gay: Readers Respond

In "Enola Gay and a Nation's Memories" (Special Report, Aug./Sept. 1994), Martin Harwit describes an exhibition the National Air and Space Museum has planned for next year that will focus on "the last months of the war in the Pacific and the role of the *Enola Gay* in bringing a fierce conflict to a sudden, merciful end for the millions of young American servicemen who were poised to sacrifice their lives for their country." If only that description matched the final draft of the exhibition script. Unfortunately it doesn't, and that is why thousands of veterans and numerous veteran organizations are opposed to the Museum's plans for "The Last Act—The Atomic Bomb and the End of World War II."

From the start, our concerns have centered on balance and context. The current script falls short on both counts. The Museum is essentially using the *Enola Gay* as a prop in an emotionally

charged program about the atomic bomb. The exhibition still intentionally builds toward an "emotional center" at the section entitled "Ground Zero: Hiroshima and Nagasaki." Taken as a whole, it still portrays Japan more as the victim than as the aggressor in World War II and America as engaged in a war of vengeance. While Japanese atrocities and Japan's sneak attack on Pearl Harbor are mentioned in passing, 82 percent of the casualties pictured in the exhibit are Japanese. Veterans will inevitably ask: What about American and Allied casualties?

As for context, the script gives weight to the view that President Truman decided to drop the atomic bomb in order to impress the Soviet Union rather than to save American and Japanese lives. This interpretation reflects the curators' biases more than the historical facts. Another problem is the way the current script treats the overall context of the war. By August 1945 our country had endured



"We've programmed the Hubble telescope to take pictures of Earth!"



four years of heavy fighting and massive casualties. Those years should form the backdrop of "The Last Act," but they are treated only in the most cursory way.

As for the many advisory committees that reviewed the script, the director of the Museum takes credit for consulting with distinguished academics and military historians and for meeting with veteran groups. What he does not tell your readers, however, is whether his curators have really listened to constructive criticism. Most of the military historians and the most recent advisory committee have been highly critical of the script. Yet

save for relatively few changes, the thrust and focus of the script have remained remarkably consistent throughout the whole review process.

Harwit singles out the Air Force Association and *Air Force* magazine for failing to provide comments to the Museum and choosing instead to attack the Museum in the media. But in fact, between August and November 1993, the association repeatedly offered constructive comments to the Museum—in writing, by telephone, and in person. Like others, we found Museum officials willing to listen but unwilling to change very much.

There is still time to go back to the drawing board and develop an exhibit that will provide an accurate and balanced view of the end of World War II. If the Museum is unwilling to do so, it would be better to have no exhibit at all.

—Gen. Monroe W. Hatch Jr.
U.S. Air Force (ret.)
Exec. Dir., Air Force Association
Arlington, Virginia

I subscribe to *Air and Space/Smithsonian* because I am fascinated by man's ability to fly, and I think I am like many of the people I've met in connection with airplanes. We like aircraft, period. Most of

us are not really interested in the dirty side of the planes, like the battle records of a Mustang, a Liberator, or a Corsair. So for the upcoming exhibit of the B-29, I'd like more of the airplane and less of the politics. As for those who are opposed to atomic bombs, just because we put a B-29 on display, does that mean we are all pro-atom bomb people who can't wait to see another one dropped? If one visits the Holocaust museum, does that mean we want to see the horrors of death camps again?

Let's make the National Air and Space Museum a place where we can learn about the evolution of man's ability to fly. On this there isn't any controversy.

—Edward C. Richter
Palm Harbor, Florida

I was there for the fighting at Okinawa and saw what it cost to take that little island. It was not hard for me to see that an invasion of Japan would take a terrible toll on both sides. We had to use the technology available to us in order to end the war as quickly as possible.

After the bomb was dropped on Nagasaki, my ship, the USS *Wichita* CA-45, was the first major warship to enter the harbor to help evacuate ex-prisoners of war. I flew over the city at low altitude

BE ONE OF THE FEW ON EARTH TO OWN A STAMP THAT'S BEEN IN SPACE.

To celebrate U.S. achievements in space, we placed a limited number of Moon Landing stamps aboard the shuttle Endeavour on its latest mission. Now you have a rare opportunity to own one of these historic stamps—incorporated into a truly unique collectible.



Collectible includes:

- An exclusive \$9.95 *Moon Landing* stamp that traveled with the astronauts aboard the *Endeavour*.
- Beautifully illustrated commemorative envelope by famed artist Keith Birdsong.
- 29¢ *Moon Landing* stamp with cancellation, commemorating the *Endeavour* launch.
- Numbered Certificate of Authenticity.

Also available—a premium limited edition of 10,000, individually numbered and signed by envelope artist, Keith Birdsong.

Reserve now while quantities last.

- ☐ Send me _____ copies of the *Space Achievement* commemorative at just \$25.00 each. Item #9859.
- ☐ Send me _____ copies of the limited edition *Space Achievement* commemorative, numbered and signed by the envelope artist at just \$69.00 each. Item #9862.

Please add 50¢ postage and handling.

Name _____ Bill my: ☐ VISA ☐ MasterCard ☐ Discover Card
Address _____ Acct. No. _____
City _____ State _____ ZIP _____ Expiration Date ____/____/____
Phone # (_____) _____ Signature _____

Check or money order enclosed for \$_____ made payable to the U.S. Postal Service.

To order, call: **1 816 545-1111** 9:00–5:30 ET, M–F

Or mail coupon to: U.S. POSTAL SERVICE
PO BOX 419178, KANSAS CITY, MO 64179-0988

Orders will be fulfilled 6-8 weeks after shuttle launch.

©1994 U.S. Postal Service 0030

 **UNITED STATES
POSTAL SERVICE™**
Stamps Worth Saving.

and was able to get a good look at the widespread damage.

Almost 40 years later, my wife and I visited the city and found a beautiful area of parks, houses, and buildings, all looking as if they had always been there. Near ground zero, there is a Nagasaki museum that is full of pictures and artifacts showing the result of the bomb blast. However, neither in the museum nor at the memorial at Hiroshima is there a single mention of the fact that Japan started the war with the United States with a sneak attack on Honolulu. As Dr. Harwit pointed out, "If we cannot mount a thoroughly documented exhibition, then we have little hope of learning from these epochal events."

I thought Dr. Harwit's point was well taken: the Smithsonian should present history as it is. I was surprised at *Air Force* magazine's position.

Commander R. K. Hallett Jr.
U.S. Naval Reserve (ret.)
Arlington, Virginia

Recently I had the good fortune to visit the excellent Experimental Aircraft Association museum at Oshkosh, Wisconsin. It was showing a scale model of a bombed-out German city, constructed by a German woman who built it from her childhood memories of World War II. It was accurate down to the flowers that were growing in the remains of the foundation.

Several of the people visiting the museum that day were foreign, and I was proud that they saw that an American museum was willing to show an exhibit

depicting U.S. bombs hitting civilian targets.

I think most Americans will approve of an accurate display of what a single American bomb did to Hiroshima. It is important to remember the good the *Enola Gay* did. I hope we also remember the damage it did.

—David A. Blasco
Fort Lauderdale, Florida

Given the emotions the subject has aroused, it is inappropriate for the Museum to use the *Enola Gay* as the centerpiece for a wide-ranging "story," even if the Museum and its director believe the story teaches a valuable lesson.

Over the years, had I looked near the Museum's Me 262 or Mitsubishi Zero for an extensive story about the Holocaust or Japan's war against China, I would not have found one. Why now must the *Enola Gay* be used to make a political statement of any kind or bear the burden of explaining the second world war to the Museum's visitors?

I believe Dr. Harwit is being less than candid about his agenda. As Museum director, he is freer than the rest of us to craft the Museum's displays in ways that please him. It may even be proper for him to do so. But he owes us all an honest description of what he is doing and why.

—Commander J.E. Lyons
U.S. Navy (ret.)
Oceanport, New Jersey

Dr. Harwit seems to be saying that the National Air and Space Museum has the only correct understanding of World War II, and that the exhibit is intended to correct the misunderstandings of those who hold a different viewpoint. Do I

detect the stench of intellectual elitism? Personally, I think U.S. veterans have a better understanding of World War II than Dr. Harwit ever will.

—Roger E. Burt
Portland, Oregon

I am 30 years old, and I am amazed and concerned that many people just a few years younger than me know little or nothing about the bombings of Japan or the immense scale of destruction that can be wrought by a single nuclear weapon. Whether out of shame, pride, or fear, we must never trivialize such things, or forget them.

—Dan Younker
Quartz Hill, California

Cat Rescue

Having read "Cat Fight" (*Soundings*, Aug./Sept. 1994), I wish that William S. Dudley, the Navy historian mentioned in the piece, would explain why a 50-year-old hulk that has rotted nearly beyond recognition is such important property that criminal charges may be filed against those wishing to restore it.

The Navy sees underwater objects as hazards to navigation, but when people remove those hazards and even try to bring pride to the service, the Navy threatens them with criminal charges. It's time the laws were changed, Mr. Dudley.

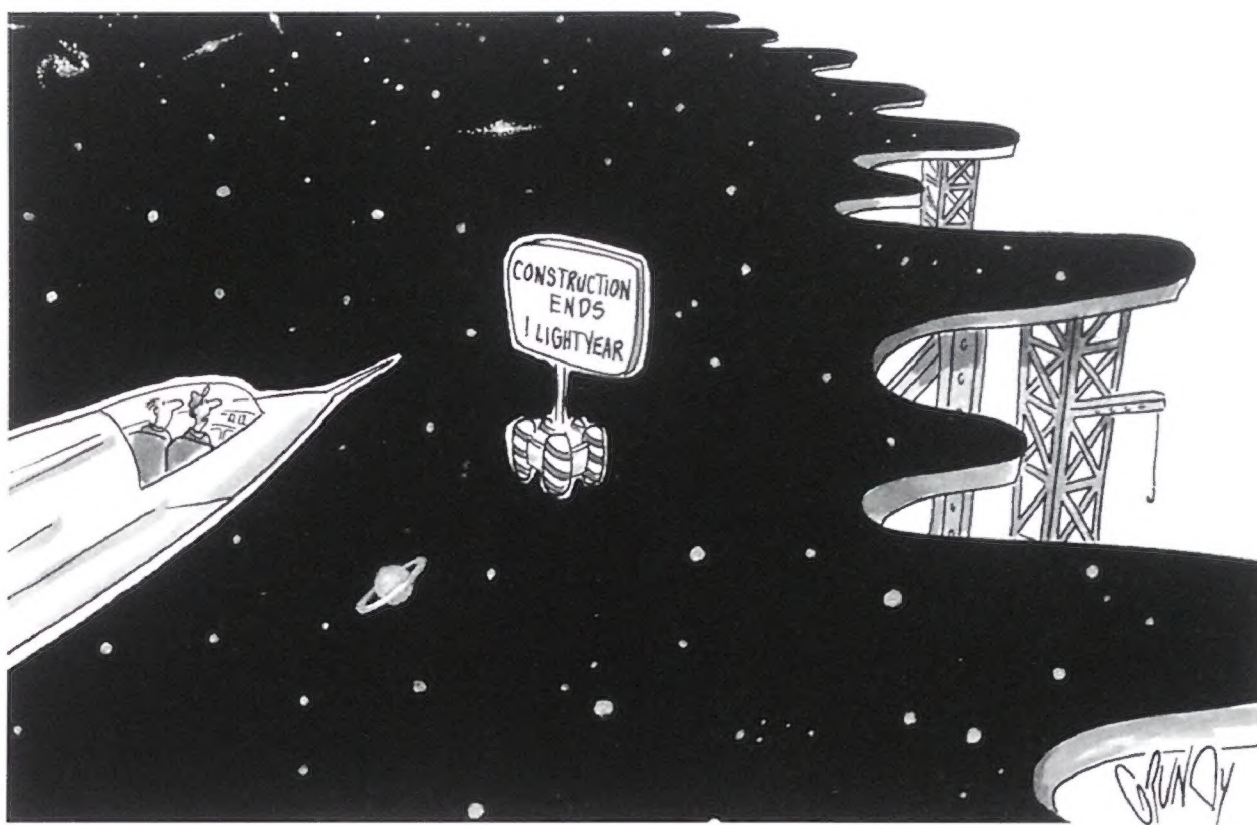
—Paul A. Ludwig
Seattle, Washington

Overkill Drill

"Oil Drill" (*Soundings*, June/July 1994) reports that a C-130H Hercules, spraying 750 gallons per minute from an altitude of 150 feet, demonstrated another way to clean up an oil spill. Who determines the success of such grandiose projects—the people who stage them? Large aircraft flown high and, of necessity, fast lay down a very wide swath that, due to the vagaries of even light winds, is largely uncontrollable. And 150 feet is high—ask any ag pilot. I doubt if the citizens of Galveston or any other coastal city would appreciate having chemicals sprayed on their doorsteps.

In very big spills at sea, such applications may make sense, but in those cases it is more likely that the action of the waves will do the job free. The British team that was imported for the Galveston test could tell you how poorly their aircraft did cleaning up a spill in the Shetland Islands.

What is needed in spill-prone areas is a mixed force of helicopters, ag planes, light twins, and four-engine aircraft under the command of a beachmaster with the



"Boy, does this ever shoot holes in the old Big Bang theory!"

authority to order out the minimum equipment necessary to do the job.

—William Burgoyne
Palmer, Alaska

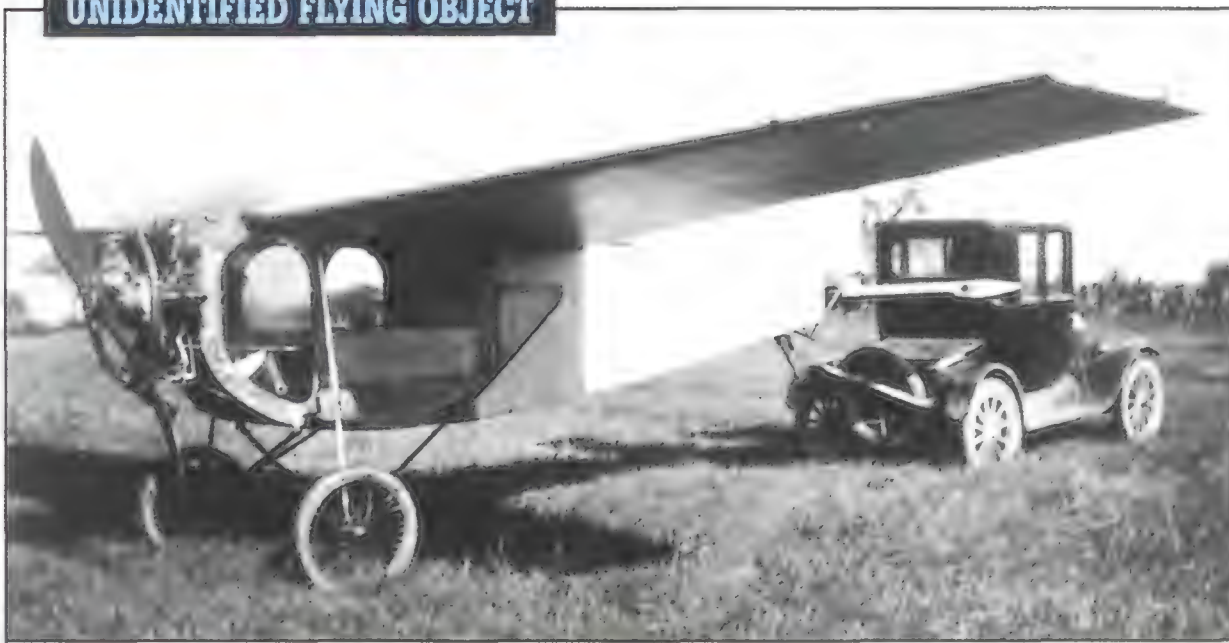
More Ferret History

William Burrows' "Behind the Iron Curtain" (Aug./Sept. 1994) missed half the story. While the ferret crews and their Ravens were flying into Soviet radar fields, U.S. Air Force radio intercept operators around the world were listening to the radar networks as they sent plotting data to their air command headquarters. We saw what their radar saw, except in Morse code. The Ravens could not tell when the Soviets were ready to send fighters or fire missiles, but we could.

Our radio traffic interceptions served as a safety net for the ferret flights. If the ferrets flew out of the approved vectors, we knew it as soon as the Soviets did, and we could have the crews alerted to change course. And if they needed protection, we could have Tactical Air Command send up fighters. It didn't always work out safely, but we still reduced crew losses.

—Peter Drachsler
San Francisco, California

UNIDENTIFIED FLYING OBJECT



Can you identify this aircraft? From time to time the National Air and Space Museum receives photographs of objects that its archivists cannot identify. The staff suspect that this airplane may be powered by an Anzani engine; other than that, they can tell very little about the craft. If you can identify this UFO, write to: Letters, Air & Space/Smithsonian, 901 D St. SW, 10th Floor, Washington, DC 20024. Please type or print clearly, and include your daytime phone number. The archivists would especially appreciate photocopies of supporting evidence.

Quite a number of readers correctly identified the Aug./Sept. 1994 UFO as a monoplane designed by German pilot Hans Grade. Flying the airplane on September 10, 1909, Grade became the first German to make an extended airplane flight.

Several readers have suggested that the June/July 1994 UFO is a Deperdussin. The archivists are not convinced, however, and would welcome further suggestions.



Imagine a Holiday Dream Come True

The Art of William S. Phillips. A Christmas Leave, When Dreams Come True.
A limited edition fine art print.

Last year, William S. Phillips' limited edition print *If Only in My Dreams* was a best-seller. Now Phillips has created *A Christmas Leave, When Dreams Come True*, a follow-up image than can fascinate on its own merits or as a companion piece.



The art of William S. Phillips is available only through authorized Greenwich Workshop dealers. For more information and the name and address of the authorized Greenwich Workshop dealer nearest you, please write or call 1-800-243-4246.

GREENWICH WORKSHOP LTD., 3751 Victoria Park Avenue, Unit 6, Scarborough, Ontario M1W 3K5, Canada • (416) 450-8342 • Toll free (800) 263-4011

© 1994 The Greenwich Workshop, Inc. All rights reserved. Printed in the U.S.A. This is a limited edition print. The number of prints is limited to 1000. The price of this print is \$100.00. The price of this print is \$100.00. The price of this print is \$100.00.

As a former member of the 343rd Strategic Reconnaissance Squadron (1951 and '52), I have one minor correction for "Beyond the Iron Curtain": the 343rd was not based at Yokota Air Base in Japan but rather at Forbes Air Force Base in Topeka, Kansas. Captain John Roche's crew was part of Detachment no. 1, a three-plane unit on temporary duty at Yokota on a rotating basis.

—Lt. Col. Monroe F. Stamps
U.S. Air Force Reserves (ret.)
Roswell, Georgia

I was an electronic countermeasures operator on a Strategic Air Command crew in 1952 and '53, and we drew Vladivostok as a target for a while. During our initial intelligence briefing, I was astounded at the quality and quantity of material provided. One would have believed the information came from someone who was able to walk the streets of Vladivostok and was perhaps in charge of air defense. But the area was closed to foreigners, so I assumed the intelligence must have come from air reconnaissance. Being exposed to the ferrets at Yokota confirmed this.

During our intelligence briefing, the briefer had the temerity to assure us that (a) if we made it out of Russia, tankers would be waiting for us over the Sea of Japan; (b) if no tankers were waiting, we could ditch and a submarine would be on station to pick us up; (c) if no submarine was there, surface ships would be sent ASAP, if possible; (d) if we were shot down and we survived, rescue aircraft would be sent in to perform a hook-and-wire snatch, one survivor at a time. The clincher was that we were issued handguns, as if they would be enough to fend off hundreds of Russians.

It has been a gross breach of faith that our military and government have not acknowledged the ferret crew members who paid the full price for our country. The families of these men have every right to be cynical.

—J.A. Perry
Lawrenceville, Pennsylvania

No Tanks

In "The Tip of the Sword" (June/July 1994), Tom Harpole says that "four tunnels, each big enough to move tanks three abreast," have been discovered under the Taebaek-sanmaek range in the Korean DMZ. From 1989 to 1993, I worked on a program to aid the Eighth U.S. Army in its search for these tunnels and have been in three of them several



D. Barstow

"We were going over those radio waves from that new star, and when you play them backward it sounds like 'Paul is dead.'"

times. In most areas of the tunnels, you must take care to keep from hitting your head on the ceiling. Our estimate is that two or possibly three soldiers, with equipment, could pass through these tunnels abreast. The tanks will have to find a different way.

—Doug Steele
RUST Geotech Inc.

Setting History on Its Head

"Thirty Seconds Over Hollywood" (Aug./Sept. 1994) says that Craig Hosking is the only pilot to take off and land in an upside-down airplane. Actually, a German pilot named Fritz Jahn did it in a specially modified Grade monoplane in 1912, and a U.S. pilot, Mike Murphy,

revived Jahn's act with a rebuilt Taylor E-2 Cub in 1939.

—Peter M. Bowers
Seattle, Washington

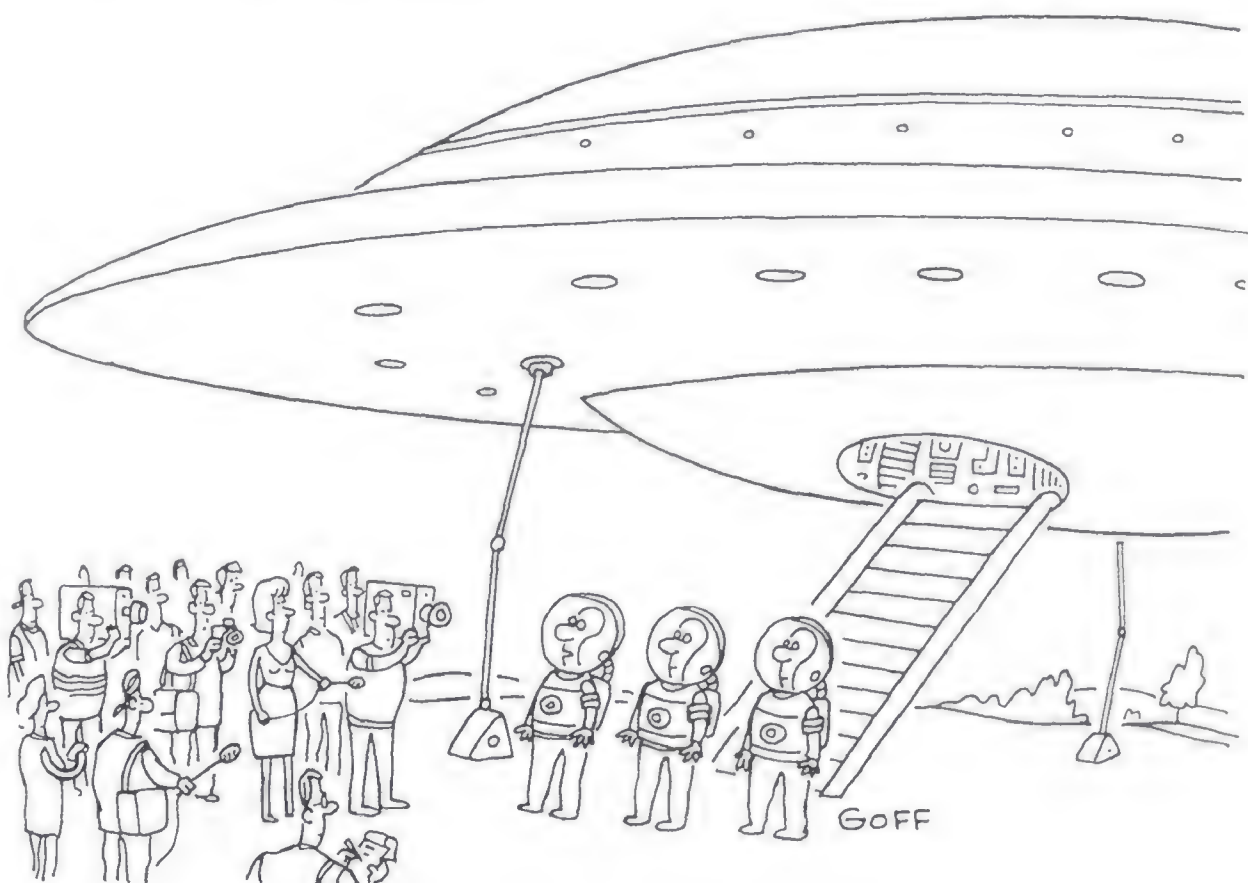
The Lowdown on D-Day

I was pilot of N3-X box 2, flight no. 2, formation position no. 2 of the 344th Bomb Group, and I was tremendously pleased to read the excellent and accurate article "Did He Say Five Hundred Feet?" (June/July 1994). I disagree with John Moench's assessment that Utah Beach was bombed from altitudes of 3,500 to 7,500 feet. To check my recollection, I called Jewell C. "Bill" Maxwell, my old squadron commander, and asked if he recalled our altitude. He immediately responded that we had flown at 1,500 to 2,000 feet. That is my recollection, and it turns out Bill and I had the same reason for remembering that figure: we had both been secretly ordered to practice with a D-8 bombsight in case altitudes got under 2,000 feet.

—John R. Stokes
Arcata, California

Address correspondence to: Letters, Air & Space/Smithsonian, 901 D St. SW, 10th Floor, Washington, DC 20024. Please type or print clearly, and include your daytime phone number. Letters will be edited for publication. Air & Space is not responsible for the return of unsolicited photographs or any other materials.

E-mail: You can contact Air & Space at airspace@aol.com. Include your full address and daytime phone number.



"We're here to kidnap tabloid journalists and perform horrible vivisections on them."

Accept this free Automatic Drip Coffeemaker, and enjoy Gevalia® Kaffe as 19th century Sweden never could.

Step back in time to the proud, century-old Swedish tradition of fine coffeemaking. We invite you to share it with the help of this free, European-style Automatic Drip Coffeemaker. Made exclusively for Gevalia® Kaffe, it is the best way we know to ensure that your first encounter with our fine coffee will be at its most flavorful.

A TASTE OF HISTORY.



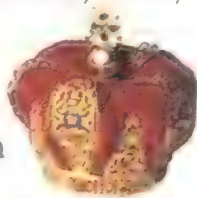
Victor Theodor Engwall

Savor a cup of Gevalia Kaffe and you will be taken back to an era when clipper ships, filled with exotic treasures from around the world, sailed the high seas. In the Swedish seaport of Gävle, they traded their riches on sun-bleached wooden docks.

Here in 1853, Victor Theodor Engwall began an importing company that led to a demanding quest.

YESTERDAY'S OBSESSION IS TODAY'S REWARD.

Over the years, Engwall's descendants became obsessed with creating a coffee as close to perfection as possible. They roasted, tasted, tested and blended the world's most prized Arabica beans, imported from lush African mountains and South American tropical jungles. Their efforts were rewarded when their coffee earned the Swedish Royal Seal—an honor still held today. Roasted with a special process and sealed in half-pound, golden foil pouches to guarantee freshness, every cup of Gevalia Kaffe is as robust and full-bodied as the Engwalls originally intended.



using the very same natural elements that put effervescence in sparkling water. The result is a full-flavored decaffeinated unlike any other you've tasted.

A WELCOME GIFT.

With your Trial Shipment of Gevalia Kaffe you'll receive your Coffeemaker in either jet black or soft white. To ensure rich flavor whether you make one cup or four, an exceptional brewing process features an exclusive aroma-lock system and high extraction filter cone.

The retail value of this Coffeemaker is \$39.95. It is yours to keep for simply ordering a Trial Shipment of Gevalia Kaffe with the understanding that if after trying it you want more, you will get further shipments through the Gevalia Kaffe Import Service. To order, complete



and send the attached order form. Credit card customers may call us toll free at 1-800-678-2687.

Complete and mail this coupon to: Gevalia Kaffe Import Service, P.O. Box 11424, Des Moines, Iowa 50336

☐ Yes, I would like to try one pound of Gevalia® Kaffe for \$10, including shipping and handling, and receive with it the Automatic Drip Coffeemaker (retail value \$39.95) as a free gift.

Please send Gevalia Kaffe—two 1/2 lb. packages of the type(s) indicated below—with the understanding that I will continue to receive shipments of Gevalia approximately every six weeks. I understand that I may cancel this arrangement at any time after receiving my introductory shipment without obligation to accept further shipments. The Automatic Drip Coffeemaker is mine to keep regardless of my decision.

Check Coffeemaker color: ☐ White (WH) ☐ Black (BL)

Check one: ☐ Whole bean (1) ☐ Ground (2)

Check one: ☐ A.Traditional Roast Regular ☐ B.Traditional Roast Decaf.
☐ C.1/2 lb. Traditional Regular + 1/2 lb. Decaffeinated

Charge my: ☐ MasterCard ☐ VISA ☐ American Express
☐ Discover Card

Card Number: _____

Exp. Date: _____

☐ Enclosed is my check payable to Gevalia Kaffe for \$10.

Please Print

Please sign here: _____

CODE: 006-934760

Name _____

Address _____

City _____

State _____

Zip _____

Phone () _____

Area Code

HOW THIS SERVICE WORKS: 1. You must find Gevalia Kaffe pleasing to your taste or you may send a postcard within 10 days after you receive your introductory supply telling us to cancel, and we will send you nothing further. The Automatic Drip Coffeemaker, in either black or white, is yours to keep in any case. 2. Otherwise, about one month after you receive your introductory package, you will receive your first standard shipment containing four packages (1/2 lb. each) of the type(s) you have indicated. Your standard shipment of 4 packages will be sent to you thereafter once every 6 weeks. 3. You will be billed \$4.45 for each package of Gevalia Kaffe Regular and \$5.25 for each package of Decaffeinated. (Prices slightly higher for Canadian residents.) A shipping and handling charge will be added. 4. You agree to pay as soon as you receive each shipment. For those using credit cards, subsequent shipments will also be conveniently billed to your card. 5. The above prices are guaranteed not to rise through January 31, 1995. 6. You may change the quantities and type of Gevalia you want at any time, or cancel the arrangement and receive no further shipments simply by notifying us. 7. Limit one membership per household. 8. Offer is open to residents of the U.S., the U.S. Virgin Islands and Puerto Rico, and now Canada.

© 1994 Vict. Th. Engwall & Co.

G · E · V · A · L · I · A · K · A · F · F · E

A SWEDISH OBSESSION



Form Versus Function

When the modernistic TWA terminal at New York's Idlewild airport (later renamed Kennedy) was completed in 1962, Senate aviation subcommittee chairman Mike Monroney called it "the most airworthy terminal the world has ever seen." Designed by Finnish architect Eero Saarinen, who also designed the award-winning terminal at Dulles airport outside Washington, D.C., the TWA building is reminiscent of a bird in flight. Its two soaring wings are supported by walls of glass, and the vaulted ceiling is anchored by Y-shaped buttresses. Inside, curved staircases gracefully connect the three levels and imply a sense of movement.

The new terminal garnered a slew of honors (including, not surprisingly, the Concrete Industry Board of New York's annual award). Last June, New York City's Landmarks Preservation Commission designated the building an official landmark, inside and out. But not everyone is celebrating.

"TWA is opposed to shutting the

terminal down and leaving it as a monument," says Marvin Mitzner, the attorney representing the airline. "That the TWA building is a significant structure is a fact most people would recognize before action by the landmark commission. TWA feels the exterior is significant, but believes that as beautiful as the interior is, it is also obsolete and requires extensive modification."

The airline, emerging from bankruptcy, has been planning alterations to the terminal's interior, including the information kiosk, baggage facilities, and the aircraft gate wings (conceived in the pre-jumbo jet age, the gate wings are too cramped to accommodate more than one wide-body jet at a time).

Fortunately for TWA, it leases the terminal from the Port Authority of New York, and unlike private owners, the Port Authority is not bound by the commission's decisions. The agency and the airline are free to view the terminal's protected status as more of a recommendation than a requirement.

Renovation plans continue, but TWA says they will be made "within the character" of the terminal.

"It's a situation we deal with every day," says Landmarks Preservation Commission spokesman George Calderaro. "We receive 5,000 applications for alterations [to landmark buildings] each year."

The landmark commission came into being after a similar incident in the early 1960s: developers had labeled Manhattan's grand old Pennsylvania Station inefficient and obsolete, razed it, and replaced it with the even more inefficient new Penn Station. In 1966 the landmark commission was formed to prevent such travesties and has since designated some 20,000 city structures as landmarks, including Central Park, Grand Central Terminal, and the Marine Air Terminal at La Guardia airport.

Port Authority executive director Stanley Brezenoff issued a statement aimed at bringing the preservation vs. practicality feud to an end. In a recent press release, he pledged to "strike a balance that will respect the spirit of this graceful and historic building and meet the needs of the thousands of people who pass through it every day."

—Phil Scott



BETTMANN ARCHIVE (2)



An Idea Flies

Journalist Chuck deCaro, who pitched his Lockheed Electra flying newsroom to the Navy in 1990 (Soundings, Feb./Mar. 1991), claims the Navy stole his "Aerobureau" idea and turned it into a battlefield surveillance craft that was recently used over Bosnia. Navy officials contend that their Lockheed P-3's video-link system was "originated in-house" and "though similar in capability, it is not a clone of the Aerobureau system." DeCaro has enlisted the aid of Representative Leslie Byrne of Virginia, who has asked for a formal investigation of the matter by the Department of Defense.

38 Special

For Michael Koziupa, March 21, 1943, quickly went from bad to worse. Although he didn't know it at the time, one of his Lockheed P-38 Lightning's two engines began belching smoke soon after he took off from Colorado Springs on a photo reconnaissance training mission. When Koziupa reached his cruising altitude of 21,000 feet, high above the Rockies, a fireball erupted from the left engine compartment and the Lightning went into a dive.

"At 2,000 to 3,000 feet, I was heading straight down at 600 miles an hour," Koziupa recalls. "I released my belt, popped the canopy, and stood up, and the air blast just sucked me out. I blacked out, and when I came to, I saw blue sky, so I pulled the ripcord."

The parachute deployed between his legs, causing Koziupa to plunge toward the ground head-first. By the time he untangled his lines, he was 500 feet above the burning wreckage of the P-38. But Koziupa caught one more lucky break: heat from the fire pushed him up and away, and he landed safely in a field.

Despite his brush with death, Koziupa, now a retired U.S. Air Force Reserve lieutenant colonel who lives in Skowhegan, Maine, considers the P-38 one of the best airplanes ever built. "It was easy to fly, it was very durable, and it served marvelously," he says.

Koziupa and several hundred other former P-38 pilots, engineers, mechanics, and ground crew personnel gathered in Houston last May to commemorate the airplane and its role in World War II. They exchanged war stories, recalled fallen

comrades, and viewed four of the seven airworthy Lightnings left in the world.

Most of all, they bragged about Lockheed engineer Kelly Johnson's legendary fighter, which looks like no other. Its engines are mounted on twin fuselages with the pilot suspended in a pod between them. The twin Allison's provide power to spare and offer a safety margin over single-engine fighters; the counter-rotating propellers also dispensed with the problem of torque. It carried four .50-caliber machine guns and a 20-millimeter cannon in its nose, which created a deadly "cone of steel," says Dick Willsie, president of the P-38 National Association. "Anything that got in the way was blasted apart."

Willsie, a retired Air Force colonel who scored three victories in P-38s, was shot down during a ground attack mission near Ploesti, Romania, the site of intense Allied bombing in 1944. He completed one last strafing run on a single engine, then landed in a field that was surrounded by German soldiers and covered with Bf 109 fighters.

Willsie's wingman, Dick Andrews, landed his P-38 about a hundred yards away. "He threw out his parachute, helped me up, and said, 'You fly,' " because Willsie, at age 24, had more flying time. "I got in, he crawled on my back, and we took off. We had to fly across the front lines, through a weather front, to a little teeny airfield in Ukraine two and a half hours away. It was a miracle, but we made it.... I've always said that the P-38 was the Cadillac of fighters. It was the most powerful thing I ever had my hands on."

—Diamond Benningfield

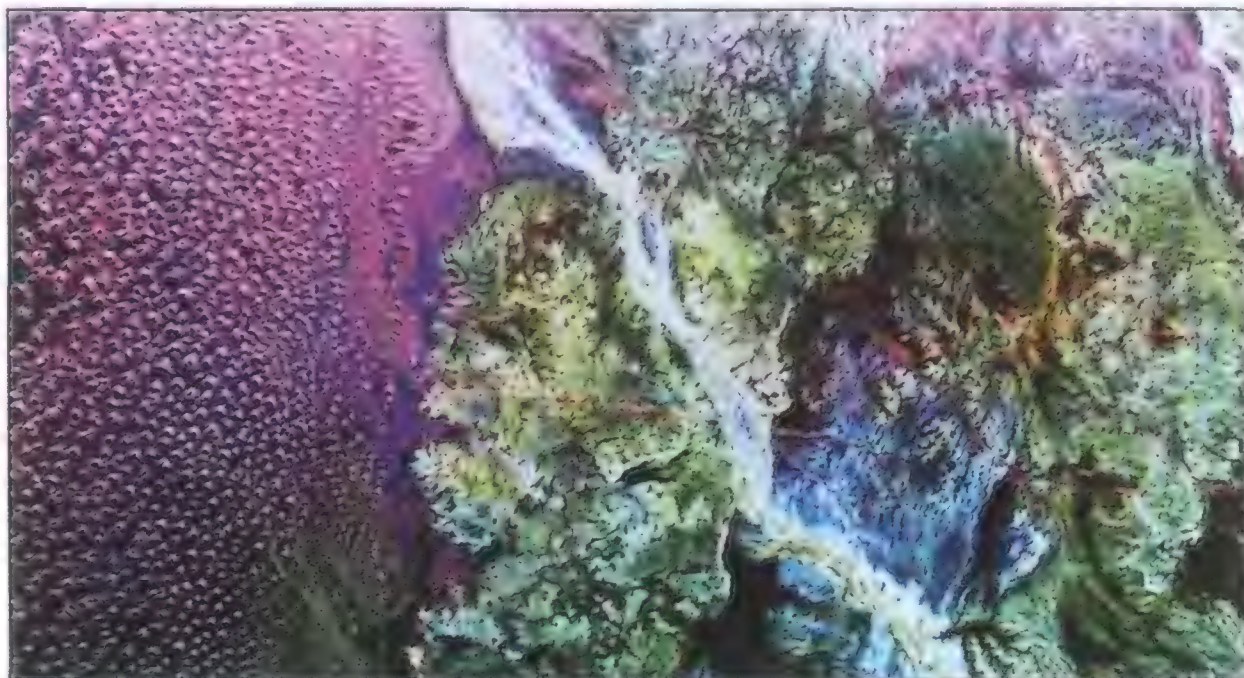
Science or Snake Oil?

The ad trotted out Madison Avenue's fail-safe icons. For men, there was an attractive woman. A bathrobe. Bare shoulders. A hint of cleavage. And the suggestive tag: "We can identify some promising areas of research." For women, just four words were necessary: *cancer, breast, ovarian, breakthrough.*

Touting the space station, Boeing Defense & Space Group, the station's primary contractor, placed the ad in *Scientific American*, *Congressional Quarterly*, *Science*, and *Space News*. "The Station will provide scientists with research conditions that are impossible to duplicate on Earth," it stated. "It will allow us to expand today's cancer research by performing experiments for extended periods of time in a true microgravity environment."

"Twenty-first century snake oil!" says Ralph De Gennaro, a director of the Friends of the Earth and a leader of Stop the Space Station, a coalition of non-profit organizations including the National Taxpayers Union and the Council for Citizens Against Government Waste. The coalition believes the ad epitomizes what the station has degenerated into: an expensive project with so little scientific merit that its possible spinoffs are now its justification, kept alive by a misleading and costly public relations campaign.

"Whoever dreamed up this ad campaign shouldn't be able to sleep at night," says De Gennaro. "This is not the way to cure breast cancer and to imply that is outrageous." He labeled the ad "cynical" in a letter to members of



Excavations in Oman continue at the site of Ubar, a desert outpost for frankincense caravans that operated from 2800 B.C. to 300 A.D. and was discovered in 1992. Sand dunes appear magenta, white indicates a dry stream bed, the rocky desert floor is green, and red streaks indicate recent trails, which overlay ancient paths. The image was made with Spaceborne Imaging Radar-C and X-Band Synthetic Aperture Radar aboard the shuttle Endeavour last April as part of NASA's Mission to Planet Earth.

Congress' Science, Space and Technology Committee last May. Indeed, Representative Carolyn B. Maloney (D-N.Y.), a member of the Congressional Caucus on Women's Issues, wrote in a "Dear Colleague" letter last June: "Space station advocates have been frantically searching for a reason to build the space station.... If we want to increase funding for [women's health research], why should we spend billions of dollars for one laboratory in space when we could use this money to fund hundreds or thousands of laboratories here on earth?" (Ironically, just days after Maloney's letter, NASA announced that technology



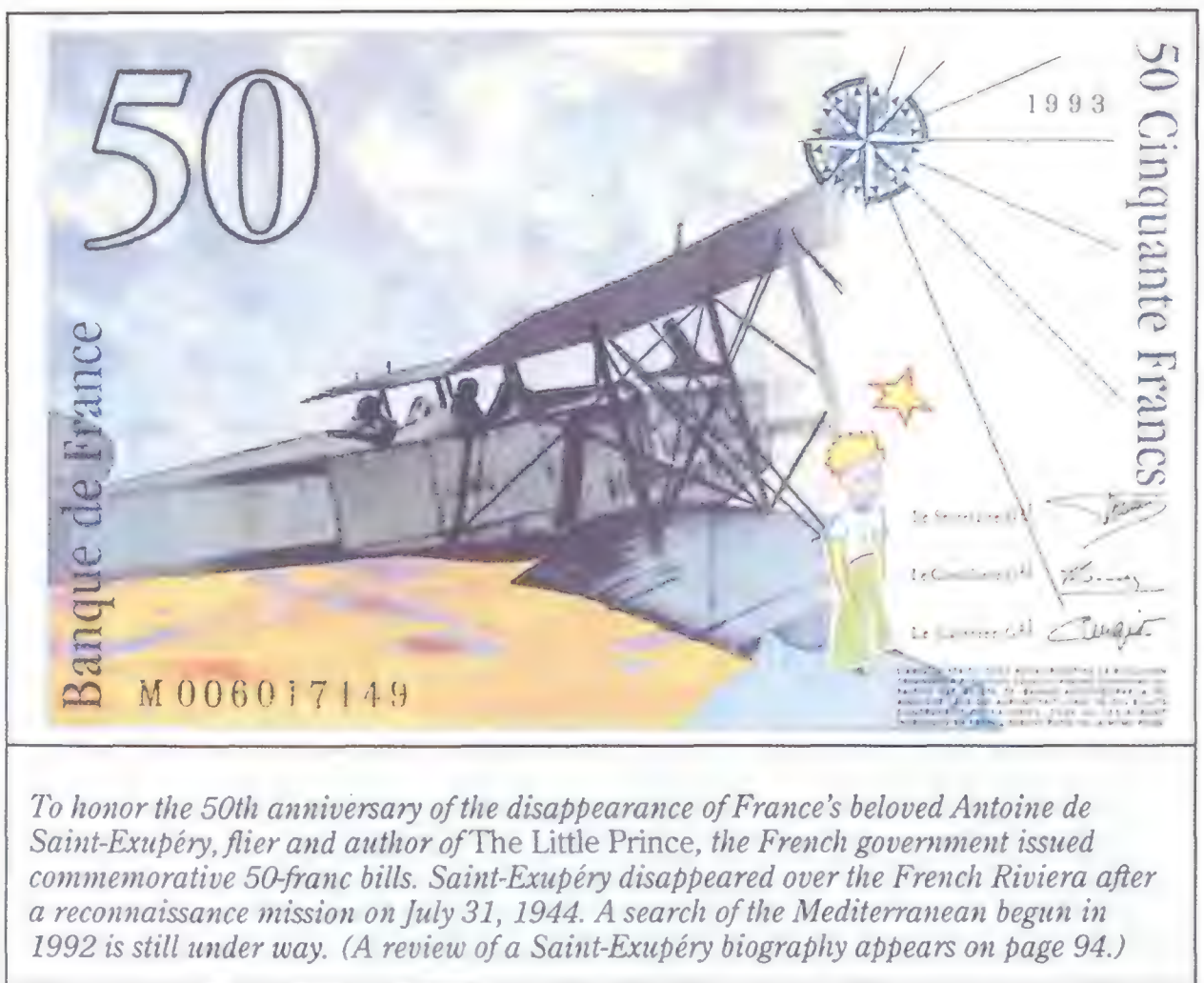
developed for the Hubble Space Telescope had resulted in a new breast biopsy technique that requires no incision and will save \$1 billion in health care costs annually.)

Nevertheless, said the American Cancer Society, "We cannot find valid scientific justification for claims that vital cancer research would be done in space." The scholarly Federation of American Societies for Experimental Biology agreed, stating: "There is a general belief in our organization that most important biological studies can be carried out satisfactorily on the ground."

Boeing, however, argues that it's impossible to predict what benefits the station will provide until it's up and operating. According to Boeing space station public relations manager Kari Thornton, the American Medical Association has endorsed it, as have hundreds of scientists clamoring for their experiments to be included. In any case, says Thornton, space station funding, which Congress recently voted to continue, comes out of a different pool than funding for, say, the National Institutes of Health. "Our position," she says, "is why not do it all?"

—Carl Hoffman

BOEING DEFENSE & SPACE GROUP



To honor the 50th anniversary of the disappearance of France's beloved Antoine de Saint-Exupéry, flier and author of The Little Prince, the French government issued commemorative 50-franc bills. Saint-Exupéry disappeared over the French Riviera after a reconnaissance mission on July 31, 1944. A search of the Mediterranean begun in 1992 is still under way. (A review of a Saint-Exupéry biography appears on page 94.)

Moon Race Redux

NASA's Marshall Space Flight Center in Huntsville, Alabama, kicked off its celebration of Apollo 11's 25th anniversary last July with a human-powered moon buggy race held on the same track used to test the real lunar rovers. Teams from six universities gathered on a rainy morning with a variety of unique designs.

The rules required that the buggies fit in a four-foot-square box prior to assembly and be light enough that its two-person crew (one male, one female) could carry it 20 feet. Texas A&M produced a fast, sleek machine that could be set up in 20 seconds, clearly making it the buggy to beat. At the very first crater-type obstacle, however, it crumpled, proving once more that graceful designs don't always work in the field. "Elegant but not robust," a NASA engineer observed.

In contrast, the University of Puerto Rico's buggy looked like someone had dumped an Erector set on the ground. When finally bolted together, it was an ugly duckling, heavy and squat. But it performed without a glitch, its enthusiastic team gaily pumping their sturdy craft round and round to the cheers of the crowd.

The University of Alabama in Huntsville had the simplest design, a tandem-seat wagon of wooden slats and aluminum tubing that promptly fell over when it encountered the first obstacle. Unhurt, its team jumped out, righted the buggy, and kept going.

After driving 20 hours straight, the University of New Hampshire team members were still spot-welding their buggy right up to race time. The Georgia Tech team arrived late and was immersed in its non-responsive steering system, and University of Indiana/Purdue University at Indianapolis, unable to get its entry in in shape for competition, simply ran out of time.

Despite the problems, all teams persevered. Scores took into account time to assemble, course time, and penalties for avoiding obstacles. New Hampshire took overall first place and won a trip to Cape Canaveral to see a shuttle launch. Special recognition was given to Puerto Rico for the best technical solution and most original design.

Race organizer Frank Six was pleased with the results. "Everybody I've talked to thinks it ought to be an annual event," he said.

—Homer H. Hickam Jr.



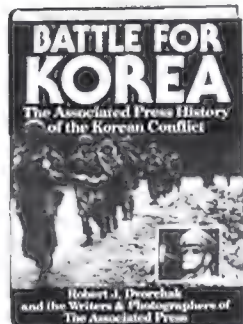
AIR SUPREMACY



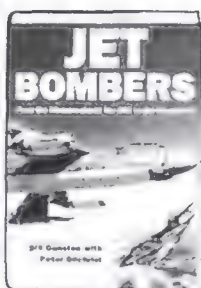
Courtesy of Northrop Corp

(and the best books on land and sea too!)

Leave it to *The Military Book Club*® to find you books that tell it like it really was. And to save you as much as 30% off publishers' prices. Just *don't* leave the coupon. Mail it today!



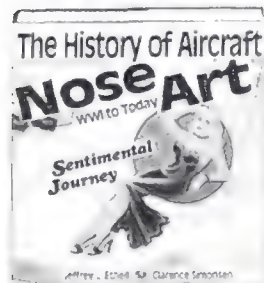
4168-9999* \$34.95



0323-9999* \$39.95



4226 \$30.00



3384-9999* \$29.95



2287 \$27.95



4721 \$12.95x

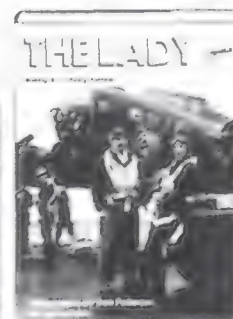
TAKE
4 for 98¢
with membership



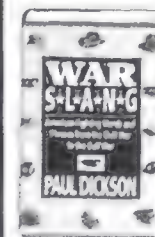
2733+ \$19.95



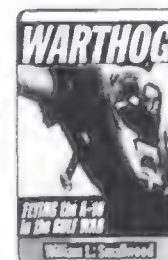
0026 \$23.00



1370+ \$15.95



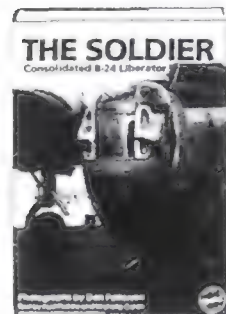
0448 \$25.00



1891 \$23.00



0521-9999* \$29.95



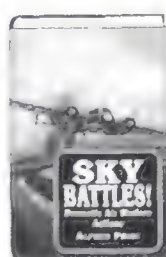
4747+ \$15.95



0315-9999* \$39.95



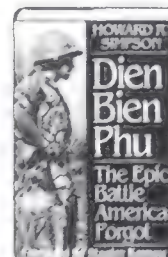
5256 \$19.95x



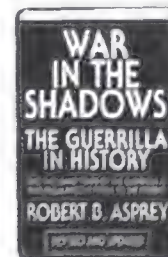
4713 \$24.95



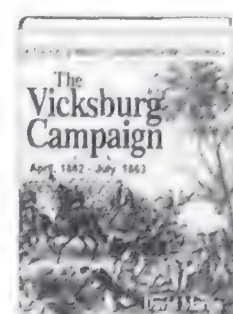
0513 \$24.95



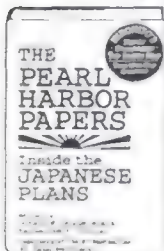
0018 \$24.00



0042-9999* \$40.00



0463 \$22.95



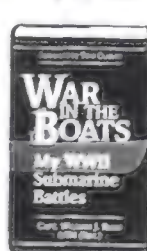
0307 \$29.95



4481 \$27.95



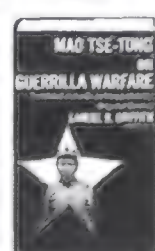
3434 \$24.95



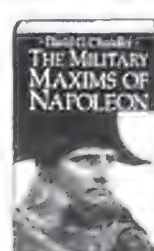
0109 \$25.00



4671++ \$22.00



2394 \$9.95x



5561 \$24.95



0182-9999* \$29.95



0075 \$29.95



0299-9999* \$35.00

HERE'S WHAT YOU GET WHEN YOU JOIN...

A GUARANTEE OF SATISFACTION. Once your membership's accepted, we'll send your 4 BOOKS. If you're dissatisfied with the books return them within 10 days *at our expense*. Membership will be canceled; you'll owe nothing.

THE FREE CLUB MAGAZINE. You'll receive up to 16 issues a year. Each reviews the Featured Book Selection(s) plus dozens of alternate books.

SHOPPING MADE SIMPLE. To get the Featured Book Selection(s), *do nothing*—it will be sent automatically. If you prefer another book—or none at all—return your Member Reply Form by the specified date. A shipping and handling charge (and sales tax, where applicable) is added to each order.

HUGE DISCOUNTS ON HARDCOVER BOOKS. Save as much as 30% off publishers' edition prices. Club books are sometimes altered in size to fit special presses.

AN EASY-TO-MEET OBLIGATION. Take up to 2 years to buy 4 more books at regular low Club prices. Afterwards, you may resign membership anytime.

RISK-FREE RETURN PRIVILEGES. If you get an unwanted book because your Club magazine was delayed and you had less than 10 days to respond, simply return the book *at our expense*.

Prices shown are for publishers' hardcover editions. Club hardcover editions save you up to 30%.

*Counts as 2 choices x Special edition exclusively for Club members + Softcover ++ Fiction

THE MILITARY BOOK CLUB ★★
Your #1 Source for Military Books

MAIL TO: The Military Book Club
6550 East 30th Street
P.O. Box 6357
Indianapolis, IN
46206-6357

Please write book numbers here:

YES! Please enroll me in *The Military Book Club* according to the risk-free membership plan described in this ad. Send me the 4 BOOKS I've indicated. Bill me just 98¢ plus shipping and handling.

SAVE EVEN MORE! Send me this book now and reduce my commitment to 3 books. Bill me an added \$2.99 plus shipping and handling. Books that count as 2 choices are not eligible.

(write book number)

57645	41
-------	----

57646 42

If you select a book that counts as 2 choices, write the first 4 digits of the book number in one row of boxes and 9999 in the next.

Mr./Mrs.
Miss/Ms. _____
(please print)

Address _____ Apt. _____

City _____ State _____ Zip _____

Members accepted in U.S.A. and Canada only. Canadian members derived from Canada where offer is slightly different. Sales tax added where applicable. We reserve the right to reject any application.

ASP 10/94

EXPLORE the INTERNET

FREE!

DELPHI is the only major online service to offer you full access to the Internet. And now you can explore this incredible resource with no risk. You get 5 hours of evening/weekend access to try it out for free!



Use electronic mail to exchange messages with over 20 million people throughout the world. Download programs and files using "FTP" and connect in real-time to other networks using "Telnet." Meet people from around the world with "Internet Relay Chat" and check out "Usenet News", the world's largest bulletin board with over 10,000 topics.

If you're not familiar with these terms, don't worry: DELPHI has expert online assistants and a large collection of help files, books, and other resources to help you get started.

After the free trial you can choose from two low-cost membership plans. With rates as low as \$1 per hour, no other online service offers so much for so little.

5-Hour Free Trial!

Dial by modem, 1-800-365-4636

Press return a few times

At Password, enter ASC94

DELPHI
INTERNET

Offer applies for new members only. A valid credit card is required for the 5-hour free trial. See DELPHI website for details.

WW 2 Leather Flying Jackets !!

From zippers to press studs and tanning process, **NO** other jackets can compare... **except** originals!

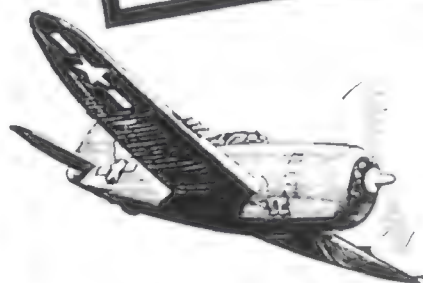
For the discriminating, Eastman's full line of rugged most-exacting WW II Flying Jacket copies: AAF, USN, RAF, Luftwaffe and a limited-edition A-2 jacket. Prices start at \$500.00 each.

Color brochure & leather samples available for \$5.00 (US), or \$10.00 (Foreign Delivery). Visa & Master Card Accepted

**HISTORY PRESERVATION
ASSOCIATES**
P.O. Box 8344
Cherry Hill, N.J.
08002-0344
Phone: (609) 234-9147



*History Preservation
Associates*
(Formerly Nose Art Unltd.)



SOUNDINGS

Pads up for Grabs

In an effort to recapture the Space Age's lost youth, the Air Force is putting two launch complexes up for adoption.

Officials at Cape Canaveral Air Station are hoping for donations of cash, labor, and professional services to resurrect the pads where Mercury and Gemini astronauts were launched into orbit in the 1960s. Lieutenant Colonel Bonnie Gervais, who administers the 45th Space Wing's Adopt-A-Pad program, envisions each pad as a tour stop. "We want to attract the companies, contractors, retirees—anybody who had anything to do with that mission," she says.

Some military standards must be upheld, as well as regulations governing historic landmarks, but Gervais says those are mere formalities. "You don't have to [commemorate] it with a gantry and a rocket," she explains. Instead of reconstructing the Mercury Atlas that lofted John Glenn in *Friendship 7*, a group could convert the Complex 14 blockhouse into a gallery of videos, photos, and memorabilia tracing the life of the pad and the missions launched from it.

The four Mercury orbital missions were launched from Pad 14, while Pad 19 was the site of 10 Gemini flights. Both sites are on the National Register of Historic Places, but little has been done to preserve them. "So much of the history has already disappeared," says Gervais. "The original gantries in many cases have been torn down. While there are some monuments out at some of the pads, we haven't done a very good job at preserving its significance."

—Beth Dickey

UPDATE

Russian Air Travelers Grounded

Citing the "unpredictable schedules and difficult conditions" of Russian air carriers, the U.S. State Department last July banned all but "absolutely necessary" domestic air travel for federal employees working in Russia ("The Unfriendly Skies," Aug./Sept. 1994). The ban will remain in place while the Federal Aviation Administration performs a safety evaluation of the air transport system in conjunction with Russian transportation authorities.



Riding Habit

Anyone who owns an unusual or rare aircraft anywhere in Britain or in some parts of the United States can be virtually certain of one thing: sooner or later they will make the acquaintance of frequent flier Edwin Shackleton.

Shackleton appears perennially in the *Guinness Book of World Records* as the World's Most Experienced Air Passenger. This is due not to the number of hours or trips he's logged but to the variety of aircraft in which he has ridden. He recently clocked his 500th type (a Hawker Siddeley Gnat jet trainer), adding to a list that includes ultralights, home-builts, helicopters, airships, hot-air and gas balloons, and military jets.

Shackleton, a 66-year-old retired British Aerospace engineer, made his first flight as a Royal Air Force cadet in 1943 in a de Havilland Dominie twin-engine biplane used to train navigators. During the remaining war years he rode in Lockheed Hudson and Ventura bombers, a Bristol Beaufort, and—highly unofficially—a U.S. Army Air Forces B-17.

Poor eyesight prevented Shackleton from becoming a pilot. He trained in the RAF as an engine specialist and in 1949 joined the Bristol Aeroplane Company's structural test department. There he worked on the Britannia turboprop airliner, the BAC 1-11, and the Concorde. Although he worked on the supersonic transport project for 18 years, Shackleton had to buy a ticket for a day trip to Egypt to fly aboard the aircraft.

Shackleton readily rattles off some high points: "Landing and taking off from an aircraft carrier deck in a Britten-Norman Islander, being one of the 45 people

aboard a balloon which set a passenger-carrying record in 1987, my 50th anniversary flight in a balloon shaped like a scotch whiskey bottle, some memorable rides with the Confederate Air Force: the B-29 *Fifi*, the unique B-26 Marauder, the one and only Stinson L-1 Vigilant, the B-24 *Diamond Lil*, and especially a trip with CAF colonel Bob Ayars in a P-38 Lightning."

Over the years Shackleton has politely but determinedly finagled his way aboard many unlikely aircraft, once hitching a ride in a Soviet An-74 military transport. But the ride of his lifetime was in his 200th type, a two-seat Supermarine Spitfire at an airshow in 1985. "Unbelievable!" Shackleton says. "I could not believe that I was actually in an aircraft type that I had seen in action in the Battle of Britain and which had become a legend in my lifetime."

What next? "Oh, there are still plenty of aircraft that I'd love to fly in," he says. "Top of my list is the Harrier, but the RAF won't let me ride in an ejector seat because of my age."

As for his other most-wanted, if anyone out there has a Martin Mars flying boat, a Ford Tri-motor, or a Douglas DC-2, don't be surprised if a genial, bespectacled man with a camera sidles up to you one day and begins, "Excuse me, I'm Edwin Shackleton. I don't suppose there's any chance..." You'll be in a very small minority if you say no.

—Mike Jerram

Dynamic Aviation Art by Dru Blair



"Power"

\$45



"Shockwave"

\$25



"Hellstorm"

\$45

**Experience the
Exhilaration of Flight
through the
Art of Dru Blair**

*Send \$5 for our full color
aerospace catalog*

**Blair Art Studios
2329 Blossom Street
Columbia, SC 29205
1-800-828-3634**

VISA/MC accepted, add \$7 S/H for lithographs



Share in America's Great Aviation Heritage



Collector Display Portfolio



You are invited to call for our free color brochure which outlines our Charter Collector Program, which allows you to collect limited edition art by America's premier aviation artist for the remarkable low price of only \$16.50 per print.

The Stokes Collection
Box 1420 Pebble Beach, CA 93953
1-800-359-4644

SOUNDINGS



NASA LANGLEY

NASA's Langley Research Center, charged with focusing on the first "A" in NASA, has added to its eclectic collection of working aircraft a Boeing 757 to be used to study the aeronautics of advanced subsonic transport. A recent group portrait features the 757, Boeing 737 (wind shear, runway friction, high-lift studies), F-16XL (aerodynamics of supersonic cruise wing), OV-10A (wake vortex research), UH-1H modified helicopter (mothership for dropping large radio-controlled models), T-38A and T-34C (trainer/chase planes), and BE-80 QueenAir and U-21A (general research support).

The Latest in Spacesuit Accessories

Construction of a U.S.-Russian orbital outpost at the turn of the century will require astronauts to spend hundreds of hours dangling from tethers. At least one overboard fall is inevitable, according to the designers of SAFER, the Simplified Aid for Extravehicular Rescue.

"There's always human error," says Cliff Hess, an engineer who supervises the \$7 million jet backpack test project at NASA's Johnson Space Center in Houston. "You take SAFER along routinely, wear it like a parachute. If it doesn't work, you're in dire straits, but if you didn't have it, you'd be in even worse shape."

The backpack is for emergencies only, unlike the powerful Manned Maneuvering Units that logged some 10 hours of free flight on shuttle missions in 1984. Martin Marietta had envisioned astronauts using its \$30 million MMUs as zero-gravity cranes to propel themselves while they hoisted and assembled large but weightless sections of space station truss.

Instead, the astronauts discovered just how tricky it is to fly them even a few hundred feet from the shuttle. Astronaut Mark Lee also points out that when you're wearing a 258-pound spacesuit, a 338-pound jet backpack is an awfully big burden. "It really won't do. You can't work with the MMU on," he says.

At a quarter of the weight and nitrogen fuel capacity of the MMU, the SAFER fits below the spacewalker's life support knapsack. Sensing an impending tumble, an astronaut pulls out a hand-held controller from the back of the unit, which automatically activates the SAFER attitude sensors. Select groups of its 24 thrusters ignite to right the astronaut in distress. "This is a small, compact safety device," says Lee, "like a fire extinguisher you've got on the wall."

Hess and Lee hope the SAFER will outperform three other proposed rescue aids—a telescoping pole, a lasso, and a gas gun—two of which petered out during development and one of which proved useless during a shuttle tryout.

—Beth Dickey

UPDATE

More Kills Than Schwarzenegger

Air combat test engagements between the X-31 thrust-vectoring demonstrator and current fighters are producing "kill ratios" of 32 to 1 and in-flight performances three times better than simulator predictions ("Stall Tactics," Apr./May 1991). Pitted against an F/A-18, the X-31, without the use of thrust vectoring, lost roughly half of the combat engagements. However, employing its enhanced-maneuverability flight control system and thrust vectoring, which allowed it to reach 70-degree angles of attack, the X-31 won 77 out of 93 engagements.

Collector's Editions

Every three months, nearly 650 readers around the world await the arrival of *The Plane News*, a slick, four-color digest for "collectors of aviation toys and models." *TPN* devotes its 28 pages to the history, manufacture, and collecting—especially the collecting—of toy and model airplanes (no kits, please).

The magazine is produced by G.R. Webster, a former Army captain who flew Huey gunships in Vietnam. Nights and weekends, Webster, now a suburban

Connecticut resident and president of the Givaudan-Roure perfume company, works on the magazine amid his collection of 2,500 models and toys.

"There was never anything about toy airplanes in hobby magazines," says Webster, so during the Christmas season of 1988, he started *The Plane News*. "To look back on it now, the first issue was just awful. I sent out, gave away, the 750 copies to people whom I had traded with or bought from and got 15 replies with checks."

TPN readers include an airline pilot, a Dutch rock musician, a TV and movie actor, an airport ramp worker, a Japanese insurance executive, several physicians, and at least one aviation historian and author. "We have a couple of members who are airline and military pilots and one member who won't fly," says Webster. Some subscribers think nothing of traveling across the country to attend one of TPN's sales and swap meets. "We've even had two members fly from Europe for a one-day show and dinner and then go right back," Webster says.

Some subscribers specialize in a particular scale. Others collect only airplanes on floats, helicopters, or autogiros. Some want the classic English Dinky Toy die-casts, some only the beautifully lithographed Japanese tin plates from the 1950s and '60s (a mint Japanese tin plate B-36 with a 24-inch wingspan commands \$1,200). Others seek the rare and pricey Danish Tekno toys, and still others collect only government-issue identification models from World War II.

A former New York City police officer, Larry McLaughlin got his first model from his father, a Grumman employee. "I was home from school and my dad brought out a model of the SA-16 Albatross and let me play with it," he recalls. After a detour as a collector of pre-World War II toy trains, McLaughlin rescued the Albatross from his parents' cellar. Like many collectors, he prefers Topping models, made by a now-defunct Akron, Ohio company.

Alex Panchenko is an entrepreneurial Russian émigré who has tapped into the collector's market. Through contacts in the former Soviet Union, he imports models from MiG, Tupolev, Yak, Beriev, and Antonov. Panchenko survived the 1993 California wildfires only to have his apartment destroyed in last January's earthquake. His first words to TPN members afterward was that the models they had ordered were okay.

"I've been in houses where a model is the centerpiece of a dining room and in another where the airplanes, gazillions of them, had been mounted in the angled space between the wall and ceiling, like butterflies," says McLaughlin. "In every room. I think there's been at least one divorce or separation too, as collecting is, as someone wrote, an unruly if largely socially acceptable passion."

—Thomas Wm. McGarry



Air & Space FALL SHOWCASE

PKZIP® PKUNZIP® & PKSPFX® Version 2.0

**with
Data Compression**

Save Space

**Reduce transmission costs
and increase floppy disk
and hard-drive
storage capacity.**

Save Time

Save Money

PKWARE® Inc.

9025 N. Deerwood Drive,
Brown Deer, WI 53223
FAX 414-354-8559
1-414-354-8699



Edmund Scientific Co. FREE SCIENCE CATALOG

Everything you need for science fair projects. Over 4,000 science educational products for all ages. Telescopes, microscopes, science discovery kits, prisms, robots, solar energy, optics, optical labs, microscopes, rocks & fossils, ant farms, rockets, and much more.

For a **FREE** 128 page catalog call 1-609-547-8880 or write.



Serving Science Hobbyists Since 1942

Edmund Scientific Co.
Dept. 14A1-C901 Edscorp Bldg.
Barrington, NJ 08007-1380 USA



MiG 29 Instrument Clock

This is the actual instrument clock installed in Soviet MiG 29 Fulcrum. With base and documents, \$249. For unique, historical optics and instruments from around the world, call:



DEUTSCHE OPTIK 1-800-225-9407

WW II Anniv. Mugs, T-Shirts & Caps



Mugs: 8th AF, P-51, P-47, P-38, B-17, B-24, B-25, Corsair, L-4, Tonkin Gulf Yacht Club, SBD-5, GB, P-51, J-3 Club- \$8.95 ea. \$4 s&h **Caps:** Emb. combat wings, 8th AF, USAAF, Navy, Combat Infantry, Marine, Photo Wings, Tokyo Raid, Battle of Britain, Tonkin Gulf Club, J-3 Club, Gee Bee Racer- \$12.95 ea., \$4 s&h **CB&AClassics** 614 Apalachee Circle North East St. Petersburg, FL 33701 **1-800-545-2661**
T-Shirts \$14.95 Most planes. Call for info. & catalog

Theme Advertising Programs, SLG, Inc 800 Second Ave.
New York, NY 10017. (212) 986-6642

My Sister, the Artist

When my sister Mary Edna and I were growing up in Fayetteville, North Carolina, our father used to fly us in the family's 1946 two-seat Ercoupe. We girls, both small enough to squeeze into the same seat, always enjoyed these short flights, which began at the dirt strip near our house and ended in the small town of Candor, where our grandparents lived.

Now when Mary Edna, 42, "flies the Coupe," she usually has her head out of the cockpit so that she can take pictures of the ground passing beneath the airplane's silver wings. She is a professional artist, and on her latest excursion, she flew over North Carolina's Outer Banks from dawn to dusk, shooting more than 500 slides. She used them, along with Landsat satellite photographs, to capture the essence of aerial light, which looks different when viewed from the ground. In flight sometimes "you can't tell where the horizon separates from the ocean," says Mary Edna. "There's a hazy area that runs from turquoise at the bottom to luminescent green."

Mary Edna Fraser (above) completed Port Washington, Long Island in 1986.

The artwork resulting from that flight, a hand-printed piece of cloth, or batik, entitled *Outer Banks, N.C.*, will be displayed with over 50 other landscape batiks in the National Air and Space Museum's first one-woman show, "Aerial Inspirations: Silk Batiks by Mary Edna Fraser," which is on display from September 9 until June 4, 1995.

My sister first got the idea of painting aerial landscapes when she and our brother Burke were flying from Savannah, Georgia, to Hilton Head, South Carolina, in 1980. Captivated by the complex patterns of the coastal islands, she's been hooked on aerial perspective ever since. She has amassed a diverse collection of aerial images by flying with charter pilots and by going up with Dad or Burke in the airplane we call the "Volkswagen of the sky." Our grandfather bought the Ercoupe in 1946 for \$2,100, and it's been a family heirloom ever since.

Mary Edna started making batiks during her senior year in college. Now she works full-time at her waterfront property on James Island, just south of Charleston, South Carolina. For each landscape batik, which takes days and often months to complete, she uses a

CAROLYN RUSSO



technique that involves painting hot wax on areas she doesn't want the dyes to penetrate. For thin lines, she uses a tjanting tool, which allows wax to flow like ink through a bowl with a copper spout. After waxing, she dyes the cloth. Then she or an assistant sandwiches the cloth between papers and heats it with irons until all the wax is removed. The heat also sets the colors. At any point in the process, an improperly mixed dye can ruin the entire work. "[Batiking] is unforgiving at every stage," she says, "so I'm always alert and conscious of details."

To help put her aerial landscapes into perspective, the Museum will hang Mary Edna's batiks next to the maps, nautical charts, and satellite imagery that she referred to while creating them. Many of the batiks are direct overlays of maps, but others are abstract interpretations. "You get to where you ignore the real landscape," she says, "and see the piece as an impressionist."

Mary Edna spent more than 500 hours on *Charleston Waterways*. The original work, which used to hang in seven sections from the ceiling of South Carolina's Charleston International Airport, allowed arriving passengers to see from the ground what they had just viewed from the sky. In 1989, the piece was destroyed when Hurricane Hugo slammed into the South Carolina coast.

MARY EDNA FRASER



THE REMARKABLE TRAVEL JACKET

A tough wash-and-wear, go-anywhere travel companion
with 10 high-security pockets!



Travellers love it, pickpockets hate it.

When travelling, you need comfortable, practical clothing *and* a safe way to carry your wallet, passport and other valuables. That's why we created *The Remarkable Travel Jacket*, an amazingly versatile jacket designed for comfort, great looks and easy care — plus protection for your valuables.

**Travel-tested wash-and-wear fabric
for comfort and style.**

The secret to *The Remarkable Travel Jacket's* stylish good looks is a special poly twill fabric that resists creasing, even after it's been stored in an airplane's overhead compartment! What's more, cleaning is a breeze. Just wash it in a tub or sink and hang it to dry.

10 secure pockets to foil pickpockets.

What's most amazing about this jacket are its *10 separate high-security pockets*, only 3 of which are visible from the outside. There are also 2 zipper-close and 2 velcro[®]-close inside pockets, 1 hidden coin pocket, and a pen pocket. Last but not least is a *super-secret* money pocket that only *you* will know how to find.

Designed and made in Europe.

The Remarkable Travel Jacket has been designed exclusively for Willabee & Ward by a venerable European producer of luxury clothing — founded in 1848 and headquartered in France. You will not find this jacket in catalogs or stores. It is available exclusively from Willabee & Ward.

**Amazing price beats competition
by a mile!**

A jacket with all these features would cost \$250 or more. But Willabee & Ward's *Remarkable Travel Jacket* is priced at just \$169 (plus \$9.50 shipping/handling), payable in five convenient monthly credit card installments of \$35.70. Available in tan or navy in men's even sizes 36-52 regular or long. Your complete satisfaction is guaranteed; if not delighted, return in original condition within 30 days of receipt for a replacement or refund. Order today!

Also
available
in Navy.

**CALL TOLL FREE:
1-800-367-4534
Ext. 769-111**

©1994 MBI

Willabee & Ward
47 Richards Avenue
Norwalk, CT 06857



Satisfaction
guaranteed.

CALL TOLL-FREE: 1-800-367-4534 Ext. 769-111

Please send me _____ *Remarkable Travel Jacket(s)*.

Size(s) (Even sizes 36-52): _____ ☐ Regular ☐ Long

Color: ☐ Tan ☐ Navy

Charge each of five installments of \$35.70* to my credit card:

☐ VISA ☐ MasterCard ☐ Discover ☐ Am. Ex.

Credit Card No.

Exp. Date

Name _____
(PLEASE PRINT CLEARLY)

Address _____

City/State/Zip _____

Signature _____
(All orders subject to acceptance.)

☐ I prefer not to use a credit card and will pay by check. Enclosed is my check for \$169 plus \$9.50 shipping/handling, a total of \$178.50* for each jacket.

*Any applicable sales tax will be billed with shipment. Higher shipping/handling outside U.S.

At the time, my sister's studio was in Charleston's historic district. Hugo leveled her studio and she lost everything: artwork, slides of past works, and tools. "The hurricane blew away my studio, tore up my yard, and wrecked my life," says Mary Edna, "but I didn't cry. Then I got a call from the airport and they said my batik was a disaster. Two years of my work was lying like rags used to mop up the floor. I cried like a baby."

Some good, however, did come out of the disaster: Mary Edna discovered that she qualified for a low-interest loan from the Federal Emergency Management Agency. She used the money to build a 900-square-foot, two-story studio behind her house on James Island. After the studio was completed, she spent the next nine months redoing *Charleston Waterways*, which now hangs from the ceiling of the rebuilt Charleston airport.

I visited my sister recently, and as we were driving to her house she noticed that the sunset over the bay had filled the sky with swatches of deep orange and blue. She stopped her mini-van along the street to study the scene. "That sky has just the range of color that I was looking for today on that Alaskan batik," she said.

Later that evening, she mixed a dye bath to match the colors of the sunset she had just viewed.

—Rebecca Burkhead

Something Like Airplanes

When Neal V. Loving saw his older brother Barney assembling a radio antenna, he wanted to string one of his own right next to it. But Barney wouldn't let him, claiming it would interfere with his own reception. While they argued, a de Havilland DH-4 mailplane chugged by overhead, and, the younger Loving recalls, "My brother said to me, 'Neal, why don't you get interested in something like airplanes?'"

That was in 1926, and for most Americans, the story of how one of the nation's foremost black aviation pioneers got started in his lifelong career has been virtually unknown. Now the Smithsonian Institution Press has published Neal Loving's autobiography, *Loving's Love*, and the story of this courageous and ultimately undefeatable man can be read, told, and retold.

In an address at the Museum's Langley Theater in early June, Neal Loving recounted some of the highs and lows that have punctuated the story of his life. With a smile that lit the whole theater, a gentle baritone voice, and a warm sense of humor, he had the gathering in the



palm of his hand.

Although a victim of the racial prejudice that barred blacks from opportunities in aviation, Loving ultimately prevailed on grit and determination. Following a 1944 crash in a glider he had designed, he lost one leg, only to suffer, in the ensuing few weeks, word from his fiancée that their engagement was over, then the unexpected death of his mother, and finally the loss of his other leg. Still he kept on in his pursuit of a flying career, something he calls a love story. "Not only did I love to do it, I was being *paid* to do it," he says.

With help from a supportive high school principal in Detroit and inspiration from Charles Lindbergh's 1927 transatlantic flight, he struggled to learn to fly, taking his first lesson in 1938 and soloing in a Piper Cub a year later—"the day I remember as seventh heaven," he says. When the war came, demand for aircraft mechanics grew swiftly, and his former principal called him back to teach. Although a city official held up the hiring-process paperwork on a technicality, some "hot language" from the principal solved the problem, and once Loving was on his way, his career never faltered, the aforementioned streak of bad luck notwithstanding. He describes things like the loss of both legs as "life's little problems."

Loving went on to design airplanes, including a racer and a folding-wing "roadable" he towed to the airport, and ultimately to conduct research at Wright-Patterson Air Force Base, where he explored a phenomenon known as clear-air turbulence that was plaguing a new generation of high-flying jet transports. He retired in 1982 after 20 years of government service.

Loving, whom Smithsonian Institution Press editor in chief Felix Lowe describes as "the most modest man I've ever met" (Loving says in reply, "I'm honest, not modest"), received a standing ovation following the address, after which he signed editions of his new book in the Museum lobby. At the end of the evening, General Earl Brown, a retired Air Force fighter pilot and Museum docent, ruminated as he was leaving for home, "I wonder how many more like him there are out there? I never even knew about him until I came to this museum." Good question. Now that his story is in print, more of the world will have an opportunity to know about a pioneer named Neal Loving.

—George C. Larson

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700 Mon.–Sat., 9 a.m.–4 p.m.; TTY: (202) 357-1729.

October 1 Monthly Sky Lecture. Ed Frederick of the New England Science Center discusses cosmic rays. Einstein Planetarium, 9:30 a.m.

October 4 Daniel Hagedorn, a National Air and Space Museum archivist, covers the highlights of Latin American aviation history. Lower level briefing room, noon.

October 6 G.E. Aviation Lecture. Former test pilot Chuck Yeager tells what it was like to break the sound barrier. Free tickets for this lecture will be distributed first-come, first-served at the theater box office beginning at 5:00 p.m. Langley Theater, 7:30 p.m.

October 11 Donald Lopez shares his experiences as a fighter pilot flying P-40s and P-51s over China during World War II. Lower level briefing room, noon.

October 12–November 9 Astronomy's Most Wanted Lecture Series. "Looking for Planet X," Brian Marsden, director of the International Astronomical Union's Central Bureau for Astronomical Telegrams, Oct. 12. "Searching for Extrasolar Planets," Robert Stefanik, director of the Oak Ridge Observatory, Oct. 19. "Finding Black Holes," Jeffrey McClintock, an astronomer at the Harvard-Smithsonian Center for Astrophysics, Oct. 26. "Missing Matter," John Huchra, Smithsonian Astrophysical Observatory, Nov. 2. "Watching Starbirth," Charles Lada, an astronomer at the Harvard-Smithsonian Center for Astrophysics, Nov. 9. Einstein Planetarium, 7:00 p.m.

Reserve Yours Now!

Air & Space Magazine's Official 1995 Calendar and Planner

In this widely acclaimed desktop calendar, each week opens with a unique image from the archives of the National Air and Space Museum or the pages of *Air & Space/Smithsonian*. You'll thrill to photographs that span the history of air and space flight, each one clearly captioned with background information. Designed to streamline your planning in a compact, beautifully bound volume that accents your office or home, the 1995 edition makes a welcome gift for friends and family.



Only \$9.95 (plus \$2.00 per planner for shipping and handling)—send a check or money order to AIR & SPACE/Smithsonian Desk Calendar, Department 0006, Washington D.C.

20073-0006 and be sure to include shipping address. For credit card orders, simply call 1-800-322-0344 Monday through Friday between 9 and 9 and ask for Item #0500.

Payment can be made with the following cards: Visa, MasterCard, American Express, Discover.

Quantities are limited, so order early to guarantee delivery in time for the holiday season.

The World's Most Extraordinary Aircraft in two beautiful full-color posters.

Now you can own these two *Air & Space/Smithsonian* posters in deluxe flat versions. Each poster measures 29.5 X 19.25 inches. The posters will be sent to you rolled, not folded!

Each poster is \$9.95 (includes shipping and handling). Or buy both for \$18.00!

Send check or money order to:
Posters, Air & Space/Smithsonian,
901 D St. SW, 10th Floor
Washington, DC 20024.



The Skunk Works:

For half a century, producers of aircraft that achieved the marvelous. Includes the YF-12A, an interceptor version of the famed SR-71 Blackbird!



The X-planes:

A program designed to expand the boundaries of aerospace knowledge, it included the X-15, a craft that flew so high its pilots received astronaut's wings!

"Bravo! Benissimo!"

When the United States entered World War I in April 1917, it relied heavily on allied air forces to train American pilots. I ended up in Italy, and took my very first flight at the Campo Scuola di Foggia Sud on December 5, 1917, and noted in my logbook that the joyride in the Maurice Farman MF-11 lasted all of eight minutes. I later wrote my mother: "I am now learning under one of the finest pilots in Italy."

That pilot was Sergeant Federico Semprini of the Royal Italian Aviation Corps. His flying skills and ability to instruct in the Farman training aircraft and Caproni Ca.3 bombers were respected by his students, his superiors, and our commander, Major William Ord Ryan. In fact, Major Ryan had included a testimonial to Semprini in a pamphlet that Semprini had written entitled *Practical Flying Hints*. Ryan had the pamphlet published in English and distributed to all the American student pilots.

Semprini was proud, cocky, confident, and totally dedicated to his work. However, the gulf between officers and



enlisted men in the Italian services was substantial, and Semprini was highly sensitive about his status as an enlisted man—on the lower end of the social scale. He could not speak English and was almost inarticulate in his own language. I think he felt slighted when several English-speaking Italian officers of aristocratic bearing were selected to demonstrate the three-engine Caproni bomber in the United States.

Unlike some other instructors, Semprini was encouraging and generally

tolerant of his students' often clumsy attempts to master the art of flying. Once, however, when I was holding the controls too tightly, he gave me a sharp crack on the back of my helmet. Perhaps his most revealing characteristic was his utter disdain of fear and contempt for those who showed it. This was made quite clear in the preface to his pamphlet: "The first requisite for an aviator is a strong and healthy body. In addition to that he must have the proper nervous and mental makeup, always on the alert and with absolute control over his body. He must not be of an excitable nature nor know fear, for aviation is not the branch of service for a man with a 'Yellow Streak.'"

The pressures at Foggia may have been greater than at other instruction centers because a shortage of aircraft and fuel and recurrent "troppo vento" (too much wind) restricted the number of training flights we could make. In addition, utter boredom was endemic. Inactivity compounded the strain.

It was with some prescience that I noted in a letter to my mother dated December 21, 1917, that "the record here has been that there has not been a casualty in two years, but believe me, somebody is sure going to break that record before long!" On January 20, 1918, two training aircraft collided over the field. Cadets Cheney, Sherwood, and Beach were killed instantly. The following day, we cadets, along with Italian, French, and English military contingents, slow-marched along the three-mile route from the airfield to the cemetery. Several aircraft circled overhead, and Italian women stood weeping along the roadside as our somber procession passed. "I am very glad we haven't flown for a couple of days," I wrote my mother, "for I am gradually getting back my nerve which I had somewhat shattered the other day. I

"Kid Death's" Work



COURTESY GEORGE HAROLD CRONIN (3)

Aviation cadet Cronin (top) trained during trying times in Italy in 1918. Crashes were common (left), but one instructor tried his best to boost morale (right).

don't mind admitting the fact that my whole system was shocked, as were those of a good many others. Some fellows immediately went on a 'champagne drive' to forget." I spared my mother the more graphic details.

The strain of flying seemed to intensify. One of my cadet friends confided that he had to stifle a strong urge to leap from the airplane when he felt a momentary loss of control.

The crashes continued. Zuckerman, whom we had nicknamed "Kid Death," had yet another crash, followed by Burgess, Grey, and Michie. "Day before yesterday, the 13th of the month, we had an extremely unlucky time of it," I wrote home. "We had enough nerve-jolting to cause several to hand in their flying resignations. One can hardly blame these fellows—they're just out of luck in losing their nerve. I'm hoping that I can keep my nerves well controlled, but I can tell you now that they are and will continue to undergo a strain that is found nowhere else in this man's army, chiefly because

Looping the Caproni in particular was expressly forbidden. Most of us thought the Italian pilots were generally overcautious—the exception, of course, being Sergeant Semprini.

The weather on the 24th of February was clear. We Semprini students were assembled on the flightline about midday, waiting for the little old lady to bring our lunch of soft cheese and hard bread. Semprini came out to the line and spoke quietly to several students, and the word quickly passed among us that he was going to do the deed. I ran back to the barracks to retrieve my second-hand camera, and when I returned many of the excited cadets also had cameras in hand.

We watched a mechanic taxi a 450-horsepower Caproni onto the active area and climb out. Semprini got in, took the controls, and taxied for takeoff. He climbed to altitude, treating us to several of his signature 90-degree banks along the way. We watched with increasing tension as he leveled off at about 11,500 feet and commenced a series of runs over

Caproni for another one. After finishing the second loop, he slowly spiraled down, landed, and taxied over to the students, who welcomed him with loud cries of "*Bravo! Benissimo! Che cosa bene!*"

The Italian authorities were less thrilled with Semprini's stunt. Punishment was threatened, but our liaison officer's intercession prevented it. Political skills evident even then, future mayor of New York City Captain Fiorello La Guardia wrote in a letter to Count Caproni, the aircraft's designer, who had great influence over the military: "Our boys are much more interested in Caproni flying and eager to learn than they were some time ago," La Guardia wrote. "I want you to know that Sergeant Federico Semprini of the Italian Army, one of our Caproni instructors, did a great deal toward showing the boys here that the Caproni was a real flying machine capable of doing everything in the air that a lighter machine can do. He not only maneuvered the machine through every possible movement, but two days ago, right over

the field, he very beautifully looped the loop twice in succession. This of course caused great excitement, and Semprini is strutting around the field, quite the hero of all the American boys.

"He seems, however, to have gotten in bad with his Italian superiors, who are considering punishing him for the violation of some rule prohibiting looping.

"It occurred to me that if you would send him a line or something for his success in handling the machine it would greatly please him and might mitigate any punishment which might be meted out."

Semprini was let off the hook, but his feat was far more than exhibitionism to us. He had given us a much needed tonic and had dispelled some of the stress

that had been accumulating for months. For me, Semprini restored a sense of what we were trying to accomplish in aviation. People today tend to forget that in 1918, aviation was young and exciting but also primitive and very risky.

Several weeks later we were treated to a thrilling exhibition by another skilled Italian pilot, and this time the demonstration was officially sanctioned. I described the event to my mother, concluding "Judging from myself, I expect everyone has fixed the day in his mind when he would be doing the same things."

—George Harold Cronin



Della Pigne and Semprini

all our work is done by yourself. At times you get mighty lonesome."

It was about this time that Sergeant Semprini began to think about demonstrating his skills with the Caproni, including looping the airplane—a feat that had been done by only one other pilot, Captain Silvio Resnati, who had been trained by Semprini. Semprini's students were well aware of his intentions and may have even prodded him along. Major Ryan and some others may have also known, but the Italian commandant did not, for he had ordered his students "not to attempt acrobatics, for these damn fool Americans will try to go them one better."

the field with lazy turns. I suppose he was looking for the best course into the wind, although the thought did cross my mind that he was also thinking about the best camera angles for his students below.

Suddenly Semprini started a shallow dive, then began a perfectly coordinated pull-up into the loop. All of us were completely silent—there was no movement on the ground or in the air except the Caproni. I stood looking straight up at the airplane through my camera's viewfinder, wondering if he was going to make it or drop out into a spin at the top. We mentally cheered him on as he completed the loop and then positioned the

The Flipper Factor

Our experimental anti-submarine airdrop homing torpedo had won the shootout with its Navy-built rival. Manufacturing design was completed. The torpedo had been designated Mk-44 Mod-0. In 1962, proofing was under way at Keyport Naval Torpedo Station in Washington state. Service issue had begun.

The proofing runs had shown us some aspects that could be improved. In August we engineers at General Electric's naval ordnance department were putting the finishing touches on those improvements during developmental exercise runs in the Florida Straits, out of our laboratory at the Key West Naval Station Annex. These runs were made against a stationary acoustic target. When the target received a *ping* from the torpedo's sonar transmitter, it sent a similar pulse back to the weapon. This echo, appearing on the run record as a tall, clean spike, directed the torpedo to the target.

One day the torpedo homing system suddenly began to pick up extraneous noise. It wasn't echoes from the target, but it was similar enough to cause the torpedo to run amok, as if it were chasing an underwater UFO.

The stationary target's echoes should have presented a torpedo closure rate equal to torpedo speed, but instead the echoes showed a target that at first would come in close, then move out again. The noise spikes varied from high to very low amplitudes and back up again, like the volume on a radio being turned up and down at random. The torpedo-transmitted *ping* was a single sharp spike; often, the extraneous noise that answered it would be two closely spaced spikes. The torpedo *ping* was tuned to a precise frequency; the "echoes" were spread across a wide band. None of us had ever seen anything like it.

We installed an amplifier in the torpedo's exercise head to independently record what was being observed. It not

only confirmed exactly what the sonar system recorded, it also showed that the noise continued after the torpedo stopped running. Sometimes the noise stopped while the torpedo was in midwater, sometimes only after it had reached the surface.

Dave Fisher, the development engineer, and Selby Venning, the Key West field station manager, had many phone conferences with Darryl Pilgrim and me back in Pittsfield, Massachusetts, often filled with long pauses while all of

Mod-1 became standard issue for the U.S. Navy for both air and surface use, but we were all holding our breath lest the noise return.

Two years later, after I had gone on to other assignments, I went to Washington, D.C., to attend a symposium on underwater acoustics. Two scientists from the Navy laboratory at Pennsylvania State University spoke about testing acoustic transducers suspended from research boats in the Florida Straits. At the conclusion, they lightened up their arcane presentation with a sea story.

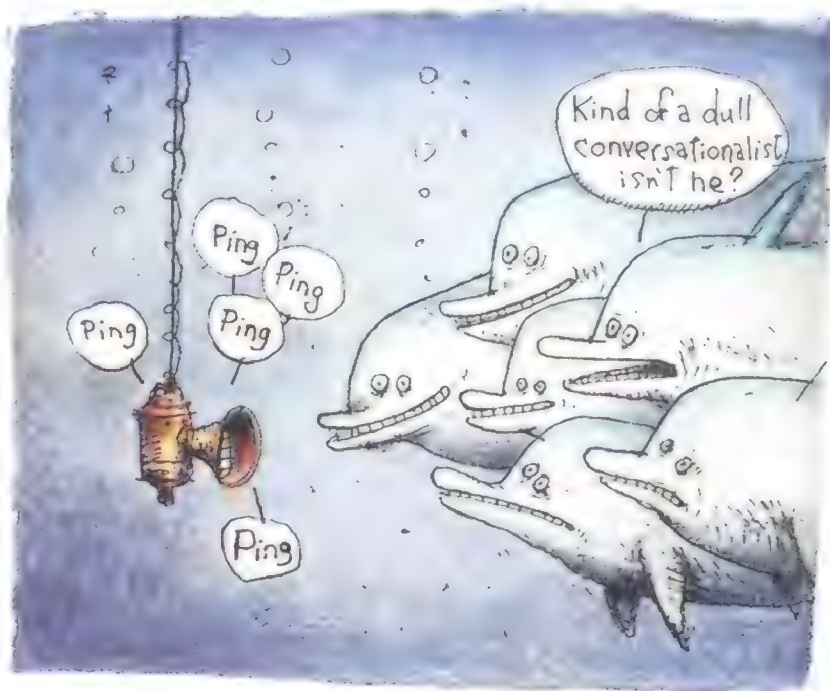
Their tests had been plagued by extraneous noise. Some days it had been so bad that they just hauled in their gear and went ashore. They showed slides of their sound records, which showed the same noise that had plagued our program. However, they had been able to identify the source: *Tursiops truncatus*, the bottle-nose dolphin. These animals seemed to be attracted by the signals broadcast by the test transducer and would gather around it and mimic the noise.

At the break I sought out the scientists and asked, "Are you sure it was dolphins that made those sounds and disrupted your tests?"

With a short laugh, one answered, "Absolutely positive. It got so that when we hauled in our transducers, the porpoise would follow them all the way to the surface, talking to them."

"Well, I guess we trained them for you," I said, and shared our experience with the runaway torpedoes. It was now obvious that the dolphins had been attracted by the Mk-44's transmitted sonar pulses, answered them in kind, and chased the torpedo as it swerved about, searching for the source of the "answers" to its *pings*. We could picture the dolphins gathering around that stationary transducer to ask where their chatty, frisky little friends had gone and when they would come back to play again.

—James V. Shannon



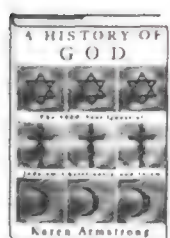
RICHARD THOMPSON

us mulled over the strange results. Finally, Venning said in half jest and complete frustration, "The torpedo's clean. There's just something out there talking to it!"

Early on the morning of October 23, Fisher called. "Sea operations are shut down indefinitely." The Cuban missile crisis had intervened.

We relocated to Keyport, Washington, to complete the testing. It took only a few runs to discover that the noise that had plagued us was gone. But why? There was a significant difference in water temperature, but what else was different? Hours of hard thinking, discussions, long-distance arguments, and more testing turned up nothing conclusive. The Mk-44

With books like these...



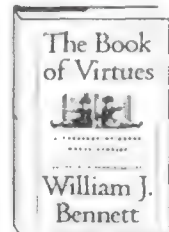
62-5862
Pub. price \$27.50



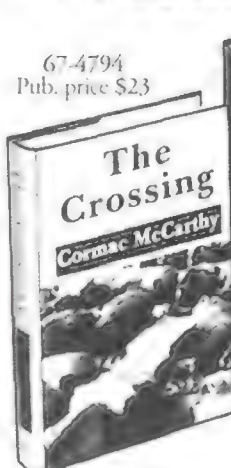
74-2880
Pub. price \$22.95



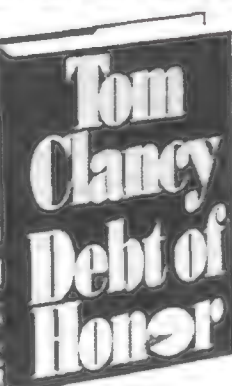
74-0488
Pub. price \$24.95



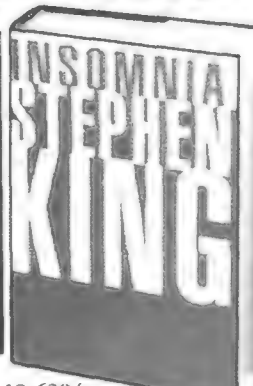
77-4192
Pub. price \$27.50



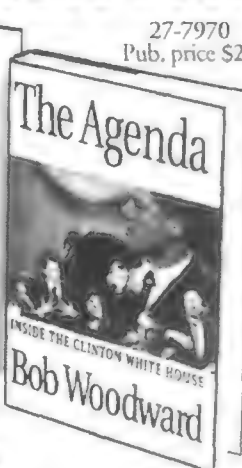
67-4794
Pub. price \$23



74-2902
Pub. price \$25.95



12-6394
Pub. price \$27.95



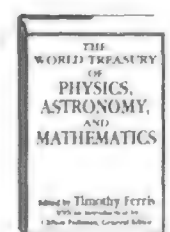
27-7970
Pub. price \$24



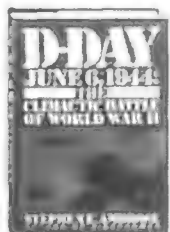
94-2134
Pub. price \$27.50



17-4180
Pub. price \$16



70-5529
Pub. price \$34.95



24-0780
Pub. price \$30

Why wait?

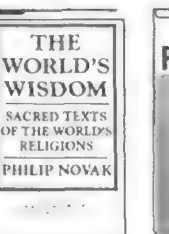
With Book-of-the-Month Club, you can stay current with the biggest names in fiction — at low prices, delivered right to your door! And this is only the beginning. As a member of the Club, you can expect a wide assortment of only the best in reading. From classics to best sellers, from cookbooks to art, children's and science books. Book-of-the-Month Club has it all. Why wait? Start your membership today!

Choose any 4 books for only \$1.

Plus, the chance to buy a 5th for only \$4.99.



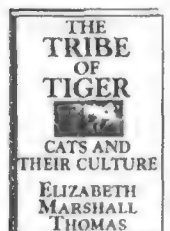
27-7850
Pub. price \$25



37-4936
Pub. price \$22



67-7380 Softcover
Pub. price \$18



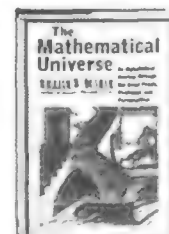
97-7078
Pub. price \$20



37-4149
Pub. price \$22.95



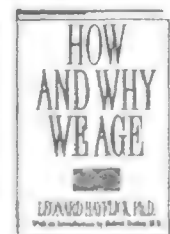
87-4218
Pub. price \$23



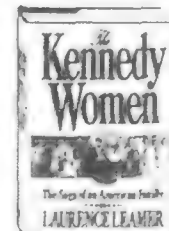
37-7979
Pub. price \$22.95



97-7584
Pub. price \$22.95



87-4886
Pub. price \$24



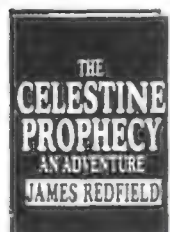
17-4975
Pub. price \$27.50



67-7838
Pub. price \$28



54-2854
Pub. price \$19.95



24-2971
Pub. price \$17.95



57-7548
Pub. price \$22



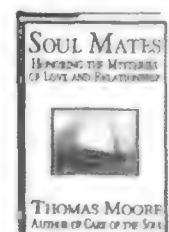
97-7158
Pub. price \$25



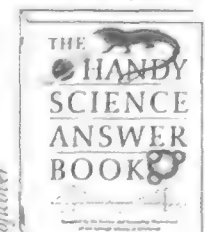
87-4193
Pub. price \$29.95



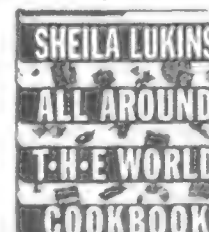
47-7483
Pub. price \$22



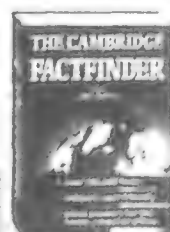
54-0798
Pub. price \$25



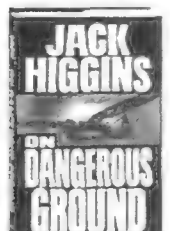
27-4598
Pub. price \$14.95



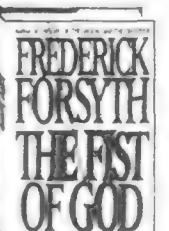
87-4796
Pub. price \$27.95



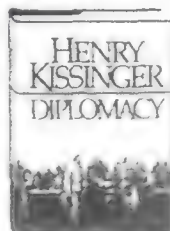
37-4158
Pub. price \$14.95



44-2996
Pub. price \$22.95



44-2861
Pub. price \$23.95



44-2804
Pub. price \$35



32-6822
Pub. price \$30



54-0709
Pub. price \$34.95



67-4609
Pub. price \$30

BOMC

Book-of-the-Month Club®
Where book lovers belong.

6 Reasons To Start Membership Today:

- 1. The offer:** Save up to \$120 off publishers' prices when you take 4 books for only \$1, plus shipping and handling. You need buy only 2 books at the regular low Club prices in the next year. **Bonus Offer:** Take a fifth book now for only \$4.99 and buy just one more book in the next year. A shipping and handling charge is added to each shipment.
- 2. You get:** High-quality books, delivered to your door.
- 3. Free:** You'll receive the *Book-of-the-Month Club* News up to 17 times a year (approximately every 3 weeks). It reviews our Main Selection and more than 200 other fine books.
- 4. Choice:** If you want the main Selection, do nothing; it will be sent automatically. If you want another book, or no book, send us the Reply Form by the given date. If the *News* is delayed and you receive the Selection without having had 10 days to notify us, just return it for credit.
- 5. No hassles:** Your membership may be discontinued, by you or by the Club, at any time after you have purchased 2 additional books.
- 6. Staying is better:** Our Book-Dividend plan offers special savings of 50% to 75% off publishers' prices.

Book-of-the-Month Club, Inc., Camp Hill, PA 17012-0001

YES! I want to keep up to date with all the best books in print. Please send me the 4 books I've chosen. I understand I have 10 days to examine them. If I keep them, bill me for just \$1, plus shipping and handling charges. I agree to buy 2 more books at the regular low Club prices in the next year.

Indicate the 4 books you want by number:

—	—
—	—

Extra Bonus Offer! Take your First Selection now for just \$4.99, plus shipping and handling. You then have to buy only 1 more book in the next year.

A003-10-0

Name

Address

City State Zip

Do you have a telephone? ☐ YES ☐ NO

Have you ever bought anything by mail in the past? ☐ YES ☐ NO

How have you paid for your mail-order purchases? (Check all that apply.)

☐ CASH ☐ CREDIT CARD ☐ CHECK ☐ MONEY ORDER

Send no money now. Mail this coupon today. All orders subject to approval. © 1994 BOMC. Please send all orders to: Canada

WHAT TYPES OF BOOKS DO YOU LIKE?

(Please circle one number for each category.)

- | | | | | | |
|--|---|---|---|---|---|
| A. Mystery/Suspense Fiction
(Tom Clancy, Agatha Christie, etc.) | 1 | 2 | 3 | 4 | 5 |
| B. Popular Fiction
(Fiction, Science Fiction, etc.) | 1 | 2 | 3 | 4 | 5 |
| C. History, Biography, Politics | 1 | 2 | 3 | 4 | 5 |
| D. Self-Help, How-To, etc.
(Cooking, Human Behavior, etc.) | 1 | 2 | 3 | 4 | 5 |
| E. Scholarly Books
(Philosophy, Science, Religion, Classics, Poetry, etc.) | 1 | 2 | 3 | 4 | 5 |
| F. Family and Fun
(Cookbooks, Crafts, Art, Travel, Pets, Humor, Children's books) | 1 | 2 | 3 | 4 | 5 |
| G. Business, Finance | 1 | 2 | 3 | 4 | 5 |
| H. Sports | 1 | 2 | 3 | 4 | 5 |

Guarantee of Satisfaction

You may examine your introductory books for 10 days, free. If you are not satisfied, for any reason whatsoever, simply return the books and you will be under no further obligation.

Ozone Forecast: Partly Cloudy

Yes, stratospheric ozone is being destroyed. But what does that mean, exactly?

by Carl A. Posey

Illustrations by Jan Adkins

A space probe would not get much from its pass above San Francisco on this winter evening. One of a parade of Alaska-size lows has spun in off the Pacific, spraying the Bay Area with great exhalations of wind and rain in time for the Wednesday rush hour. But something besides water is in the terrestrial air tonight—something that, in the absence of some verifying observation, some ground truth, could also prove impenetrable. The obscuring stuff is orthodoxy, and, here, tonight, it has the scorched smell of ozone.

On the ground, hundreds of keen observers of our planet have assembled for the week-long winter congregation of the American Geophysical Union. One of them is William Brune, a chemist from Penn State, who is giving a lecture entitled "Earth's Fragile Ozone

Layer" at the Exploratorium. Brune, a slender, bespectacled man of 30-something, opens by telling the audience what he plans to do: "I'm going to talk about ozone and especially the ozone hole. Although you hear about doubts, we are going to dispel those." He then describes a problem that has entered the public wisdom in a simplified form.

Solar ultraviolet radiation has created a shield of ozone—a molecule made up of three oxygen atoms—in the high stratosphere that absorbs the biologically dangerous mid-ultraviolet wavelengths. In recent decades, however, chlorine has been migrating into the stratosphere in molecules of industrial substances called chlorofluorocarbons, or CFCs. Once freed, chlorine catalytically attacks ozone, and as it nibbles away the shield, more and more lethal radiation reaches Earth, causing an epidemic of skin cancer and all kinds of biological effects. Brune speaks ominously of a shattered oceanic food chain,

of land plants stunted and withered by this invisible light, of a weakened human immune system; one feels the audience tense with this city's special awareness of the modern plague.

In the mid-1980s, Brune says, any doubts about all this should have been laid to rest by the detection of a massive depletion of stratospheric ozone—a broad, deep diminution that has come to be called a hole—over Antarctica, where the "smoking gun" of reactive chlorine was found in great abundance. And there are signs that stratospheric ozone over the Arctic—and even over the middle latitudes—is chemically primed with chlorine and waits only for enough sun to begin thinning the shield there, where people live. Stratospheric ozone, he intones, has never been in such short supply.

But the global consumption of CFCs is falling off, he says, relaxing a little. "People are getting out of the business." The troublesome compounds should be phased out by the end of the century, if not before. And yet, there is still a problem—a matter of belief. Brune's last slide is a child's sketch of penguins



NASA/CHAD SLATTERY (INSET)

The atmosphere provides Earth with a thin blue line of defense against the sun's deadly output. Research conducted with NASA ER-2s (left) and satellites as well as ground-based observations show that the atmosphere's protective shield of ozone is being eaten away.

wearing hats and sunglasses, clutching bottles of sunblock. Against that backdrop, Brune explains that there are people who do not wholly agree with the chemists. Standing a bit to the conservative side of him and his colleagues, he says, are certain meteorologists, well-intended people no doubt, but...well, they aren't chemists, are they? To their right, Brune says, are the fringe media that question the motives of the chemists, and the Larouchers, the crazies, who think there is no ozone problem at all. The revisionist science loose in the world, Brune suggests, is as reprehensible as the revisionist history that denies the truth of the Holocaust.

To almost everyone, the matter of ozone depletion by industrial chemicals is a problem well down the road to solution. So why is Brune scaring his mostly young audience with references to the immune system, skin cancer, and Holocaust denial? Because, he seems to be saying, he and his fellow chemists have saved the world from something terrible and would like attention to be paid. *That* is his plaintive message on this stormy night in San Francisco: What he has done from his undergraduate days until now, he wants us to under-

stand, was worth doing, no matter what the revisionists say.

Atmospheric chemistry, in a substantial way, got a big shot in the arm from CFCs," says F. Sherwood Rowland, a chemistry professor—one might say *the* chemistry professor—at the University of California at Irvine. Among the teeming youngsters of the American Geophysical Union, Rowland cuts an impressive figure: a big sixty-ish man in the blue blazer, tie, and short-sleeve white shirt that define the senior scientist or engineer in California. His large, kind face framed by white sideburns, his manner a blend of gentle modesty and casual certitude, he talks about the ozone trade with an ease that reminds one how often he must have told his story over the past two decades.

Radiochemistry was his doctoral specialty. Back in the 1950s most atmospherically inclined chemists were working on bomb diagnostics—figuring out what nukes would add to the atmosphere, where the stuff would go, and the like. Then fate stepped in. In 1972 British chemist James Lovelock invented a way of measuring the trace amounts—on the order of 40 to 80 parts per trillion—of CFCs in the atmosphere.

CFCs were so wonderfully inert that they floated around eternally, not bonding, not dissolving in water—nothing. They were the ultimate designer chemical, built to do a certain kind of work

as refrigerants, spray can propellants, and a host of other applications in which chemical reactions were just what you didn't want. Lovelock's breakthrough was good news to atmospheric researchers—such relatively immortal compounds would make excellent tracers of air mixing between the lower atmosphere and the stratosphere. To Rowland, however, it was a puzzle. "Being a chemist and not a meteorologist," he explains, "I knew that something would happen sometime. It was just a game to me if we could tell what."

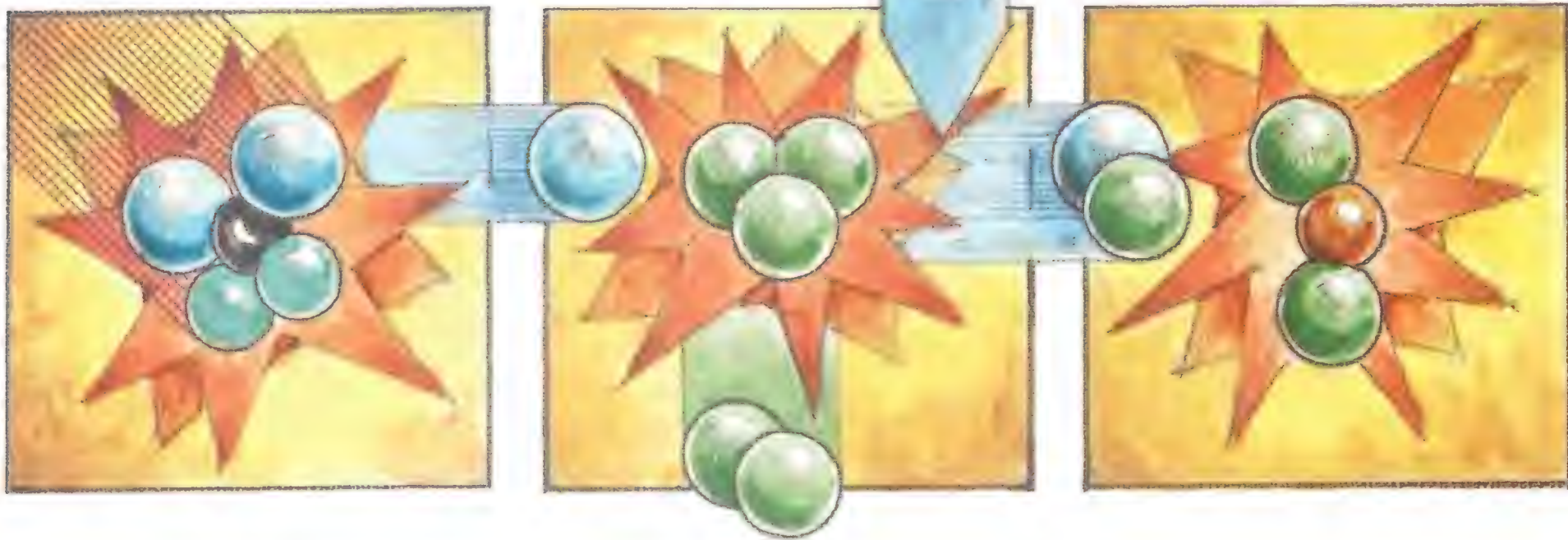
With Mario J. Molina, a post-doc from Mexico City now at MIT, Rowland began to probe. "If none of the processes that usually affect molecules in the stratosphere affected CFCs, what about interaction with ultraviolet?" he recalls wondering. "You always knew you could find a short, hard ultraviolet which will cause CFCs to decompose." From there he and Molina followed the thread from ultraviolet radiation back to the stratospheric ozone layer. He smiles. "In the simple sense, we'd solved the problem." CFCs would ultimately be ripped apart by ultraviolet radiation in the interval between about 1,900 and 2,800 angstroms in the ultraviolet spectrum, which runs from a near-visible wavelength of 4,000 angstroms down to 1,900 angstroms (an angstrom is a ten-billionth of a meter).

But what about the atomic remains of the CFC molecules, especially the chlorine? Rowland and Molina inferred to their horror that the chlorine would recycle through a lethal chemical dance, each atom killing off 100,000 or so ozone

Chlorofluorocarbons are stable in the lower atmosphere. In the stratosphere, ultraviolet breaks them down...

...releasing chlorine, which reacts with ozone. The ozone releases molecular oxygen...

...and chlorine monoxide (ClO). Two ClO molecules can then combine (not pictured) until ultraviolet releases the chlorine atoms, which destroy more ozone. Or ClO can combine with nitrogen dioxide...



There's no doubt that chlorofluorocarbons destroy ozone (above). There are a number of players in the process (below), which create their own complications.

molecules during its lifetime. What had begun as an interesting experiment had become a scenario with serious environmental repercussions. They could see chlorine removing stratospheric ozone faster than ultraviolet radiation could create it.

Other researchers were by then trying to identify the possible chemical enemies of ozone, mainly to assess the environmental impact of high-flying supersonic transports. A chain reaction between chlorine and ozone had been identified but caused little concern—until Rowland and Molina's research, no one had identified a source for stratospheric chlorine. Their first paper appeared in the June 28, 1974 issue of the

British journal *Nature*. It was, Rowland says, his 171st published article, and, as he'd anticipated, it was a bombshell.

At the National Oceanic and Atmospheric Administration's aeronomy laboratory in Boulder, an urgent environmental problem was just the ticket: the lab's peerless work on the no-man's land where the atmosphere vanishes into space had begun a slide toward irrelevance. The epitome of solid basic research, its link to the human condition often seemed tenuous. Ozone steered the lab back toward the mainstream.

Using helium balloons and valved stainless steel flasks, the aeronomists proceeded to map the vertical distribution of CFCs, first around Boulder, then around the world. Sure enough, the proportions remained about constant until the CFCs reached the stratosphere, then fell off sharply. Circumstantially, at least, this verified the Rowland-Molina idea that the hardily inert compounds were rising to ozone

layer altitudes before being destroyed. Larger balloons also probed the stratosphere. Gradually, what had been suggested by the early models of Rowland and others could be discerned in the real atmosphere.

Of course, the stratospheric world sketched by Brune on this rainy night, the one that entered the public vocabulary after Rowland and Molina's leap of insight, is not quite what spreads above us. The ozone layer is not a layer at all but a kind of thin smoke; the destructive chemistry requires some prodding to proceed; and, like everything in the atmosphere, there are the largely unpredictable wild cards of solar radiation, wind, water, and other varieties of chemical smoke to trash the neat stuff of theory.

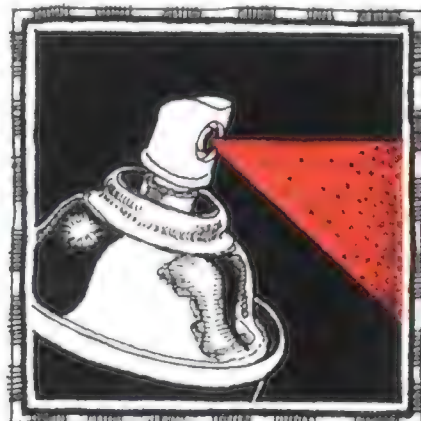
Most of the atmosphere's thinly dispersed cargo of ozone is manufactured over the tropics at altitudes of around 120,000 to 150,000 feet. Incoming "hard"



SOLAR ACTIVITY



POLAR VORTEX



CFCs



POLAR ICE CLOUDS

...to form an inactive "reservoir" molecule: chlorine nitrate. Antarctic ice clouds provide a surface on which chlorine nitrate can combine with another reservoir molecule, hydrogen chloride...

...to form nitric acid and two bound chlorine atoms.

When spring returns to Antarctica, ultraviolet light splits the chlorine atoms, which return to the cycle and destroy more ozone.



ultraviolet radiation shorter than about 2,400 angstroms splits oxygen molecules, normally composed of two oxygen atoms, into single atoms that recombine with normal oxygen molecules to form ozone—triatomic oxygen—and normal oxygen molecules. The ozone, in turn, is destroyed when it absorbs ultraviolet radiation. About as much ozone is formed as is destroyed, and the ultraviolet radiation in the B region—from 2,800 to 3,200 angstroms—is mostly kept from reaching the planet's surface.

Theoretically, radiation would create more ozone than is seen; the equilibrium appears to be sustained by ozone-destroying reactions involving nitrogen compounds migrating from natural sources on the planet's surface into the stratosphere. Because much of this drifting nitrogen has a biological source, the process is used as evidence for the idea that the planet and its life are integrated and mutually regulating.

On the front lines at 150,000 feet, the

lifetime of an ozone molecule is reckoned in minutes. But some of the ozone sinks to a lower, safer stratospheric altitude, where it is protected from dissociating radiation by its higher comrades. At these lower levels, ozone may endure for years, fanned toward the poles by mid-stratospheric winds. Thus, most of the atmosphere's ozone—the thickest plume of the smoke—is at middle and high latitudes, not over the tropics. About 90 percent of this ozone drifts at altitudes between 65,000 and 100,000 feet, with some of the remainder descending into the troposphere, the lowest layer of the atmosphere, which all living things call home.

People began measuring ozone back in the 1920s, and have measured it from a global network of surface instruments since the late 1950s. The instrument used is the Dobson spectrophotometer. The quantity is expressed in Dobson units, which derive from a quaint atmospheric image. If the air in the en-

tire column of the atmosphere were brought to normal temperature and pressure, the image goes, it would be a column of mixed gases about five miles high. If the ozone in that column were separated out and brought to the same conditions, it would be only about three millimeters high. That nominal ozone column equates to about 300 Dobson units. Of course, the nominal is not the same as the real. As the ozone smoke drifts across the sky, sometimes there are 500 or more Dobson units; sometimes, as in the Antarctic spring, there are a mere 150 or so.

Varying in the chaotic way of particles in smoke, the amount of ozone is also subject to enormous systematic swings. There is more as one moves poleward from the equator, and there is more in spring than autumn. When solar flares boost the sun's ultraviolet output, slightly more ozone is created; when the sun is quiet, ozone declines. The eruption of a large volcano is often



VOLCANOES



SEA-SURFACE TEMPERATURE



WIND DIRECTION



CLOUD COVER



followed by a thinning of ozone. Ozone increases behind a cold front, where ozone-rich air is descending, and decreases ahead of a storm, where air is rising. These natural variations, which pump up or reduce the amount of ozone in that imaginary column by as much as 50 percent, are written on a meager, patchy plume of gas blown around by stratospheric winds.

In the years that followed publication of the seminal 1974 *Nature* paper, what everybody was calling the ozone layer displayed yet another characteristic: it would not cooperate with theory. During the 1960s observers had noted that total ozone appeared to increase around the world by several percentage points. During the 1970s it showed little or no change. A slight diminution of ozone over North America seemed to follow the CFC destruction hypothesis, but nobody could tell whether the decline was natural or chemically induced. If chlorine released by disintegrating CFC molecules was destroying ozone, it was not doing nearly the damage Rowland and Molina had predicted.

Then Rowland made what seemed a happy discovery: the freewheeling chlorine oxides that should have been cycling through successive incarnations probably would not cycle after all. Instead, they would emerge from the protection of their CFC molecule, catalytically destroy an ozone molecule or two, and vanish into the non-reactive cluster of atoms in a newly formed molecule of chlorine nitrate. The chemists had known of the reaction, but they were pleasantly surprised by the longevity of the non-reactive chlorine nitrate molecules. What had seemed to hold the potential for catastrophic destruction of stratospheric ozone was suddenly back down in the statistical noise of natural variation.

And there the matter might have rested, had the south polar stratosphere not produced its famous ozone hole.

As the sun's direct rays shift northward during the southern autumn, the atmosphere over Antarctica sinks gradually into darkness. The howling winds that circle the cliff of low pressure banding the planet at those latitudes harden into what is called a polar vortex, isolating the atmosphere over Antarctica from the mixing processes that, in other seasons, make it more like the rest of the global atmosphere. Whatever is there as the sun retreats will be there when the sun returns in September to warm, and weaken, the polar vortex. If there are chemical time bombs stored in the deep freeze, the sun's rays may trigger them before fresh air sweeps in through the breached vortex.

In 1985, scientists with the British Antarctic Survey reported a precipitous drop in total ozone abundance over their station at Halley Bay. They had begun measuring ozone there in 1956. Since 1977, they said, ozone had declined steadily year by year during the austral spring, the months of sunshine over the Antarctic. But not until they found a similar decline in ozone over a second station did they begin to believe their instruments. The average total ozone in this season had been about 320 Dobson units from 1957 until 1964; by 1984, it had dropped to fewer than 200 Dobson units.

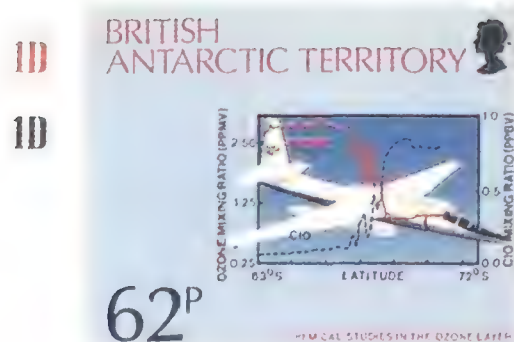
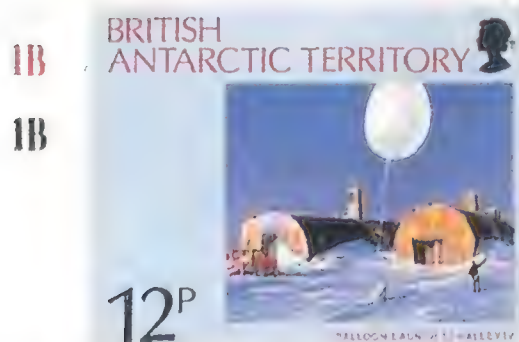
Other ozone measurers had seen the decline and attributed it to bad data. Low values obtained by the ozone-sensing satellite instrument that had been flying since 1978—the TOMS, or Total Ozone Mapping Spectrometer—were automatically discarded as erroneous by NASA computers at home. This soon changed, and the TOMS revealed a horizontal region of seriously depleted stratospheric ozone covering millions of square miles—the ozone hole.

"A well-planned-out experiment," says Susan Solomon about the British discovery. Solomon is now a research chemist with NOAA's aeronomy laboratory and a catalyst for ozone explorations. Back when Rowland and Molina published their first ozone-CFC paper, Solomon was an undergraduate at the Illinois Institute of Technology in Chicago. It was, she says, a very traditional laboratory environment. But she was also interested in doing "chemistry on a planet instead of in a lab." After working on her Ph.D. at the University of California at Berkeley with Harold Johnston, who was probing the relationship between supersonic transports and the ozone layer, Solomon went to the Na-

In 1985 a British team in Antarctica reported an ozone hole, a discovery honored in stamps (above).

F. Sherwood Rowland co-authored a 1974 paper that called the world's attention to the ozone problem.





tional Center for Atmospheric Research in Boulder and then, in 1981, joined NOAA and began doing theoretical modeling of mesospheric and stratospheric chemistry, auroral effects, and other aeronomic processes.

The magnitude of ozone depletion reported by the British was far greater than anything modeled, especially since Rowland's later model indicated that most chlorine would be tied up in non-reactive chlorine nitrate. "We did an experiment with chlorine nitrate," Rowland recalls. To their surprise, the stuff was not inert: in what Rowland calls "the fastest reaction we'd ever seen in the lab," it split chemically to release chlorine. He took the numbers to a computer and added them to the ozone depletion equations. Where they had been down to a predicted four percent depletion, the computer model now gave them 32 percent.

"To make chlorine effective, something had to liberate it from hydrogen chloride and chlorine nitrate," says Solomon. "It occurred to me that surface reactions might be it." This chemistry—the gas hitting a surface and reacting—is similar to the process that makes catalytic converters work in cars. But where was the surface in the stratosphere? Solomon fielded the idea that there was another player—the ice crystal clouds that form when the high polar stratosphere is very, very cold. If chlorine compounds dozed in those ice crystals, she surmised, the returning sun would revive them and the ozone-destroying chemical dance would resume. That, she believed, had caused the southern ozone hole.

In the austral spring of 1986, she led the National Ozone Expedition to Antarctica's McMurdo Sound. The team arrived in time to see normal ozone levels decline by about 35 percent and found greatly elevated levels of chlorine oxides in the stratosphere—the smoking gun of Brune's presentation. The following year, a high-flying NASA ER-2 and other instrument-laden craft worked with the surface teams to illuminate the ozone depletion further.

The new urgency induced by the Antarctic depletion sent the researchers hurrying toward the other pole in search of similar holes. In Greenland in February 1988, Solomon says, they found less chlorine oxides than in the south, but more than there should have been. A year later, flying out of Stavanger, Norway, ER-2 instruments again detected elevated levels of chlorine oxides, although still less than there had been over Antarctica. "That was when I began to think it was starting to get a little bit scary," she says. "Seeing it in the Antarctic, away from population... was different." She adds, "You can't do this kind of work without thinking about the ghoulish nature of what you're doing. I wish we could have some good news, but it just keeps getting worse."

Not everyone was that eager for good news. NASA, with its Mission to Planet Earth satellites coming on line, seemed to have been foraging omnivorously for something to show how clearly its airplanes and satellites could see an unfolding environmental crisis. As the agency has sometimes done, it rushed its early results to the press, of-

ten tricked out as alarms.

At a February 1989 press conference, NASA scientists said their ER-2 flights out of Stavanger into the northern polar vortex had found elevated levels of reactive chlorine compounds and, yes, some ozone depletion—not a hole, exactly, but less than the usual seasonal increase. The added ingredients needed to make the southern depletion work—a stable, isolating polar vortex, abundant chlorine, polar stratospheric clouds, very cold temperatures, and sunlight—were simply not present. They rarely are: the coldest Arctic winters are warmer than the warmest Antarctic winters and the northern vortex is unstable and vastly complicated by landmasses and open ocean. Polar stratospheric clouds are the exception rather than the rule, and the returning sun swiftly sweeps away what vortex there is before solar radiation has a chance to push the chemistry.

By the end of the experiment, NASA reported it had found "no unequivocal signal" of CFC-induced ozone depletion. Then, brightening somewhat, the scientists concluded, "When we left Stavanger, the vortex was primed for ozone destruction." If the sun would return a little sooner, if the vortex would hold up—if, in short, the Arctic would stretch itself a bit and become more like its southern cousin—something terrible might happen to the ozone.

Several years later NASA tried harder, warning in a February 3, 1992 press release that an ozone hole was increasingly likely over the high northern latitudes, where people live. A second, six-month-long airborne expedition



had found record abundances of chlorine monoxide over eastern Canada and northern New England. Such chlorine levels, the scientists warned, with other chemicals thrown in, could reduce ozone by one or two percent per day during the brief interval of January sunlight at these latitudes. A second press release of the same date reported that elevated levels of chlorine monoxide had been detected by NASA's Upper Atmosphere Research Satellite over populated areas of Europe and Asia north of about 50 degrees latitude—the latitude of Frankfurt, Prague, and England's Land's End. (European scientists likewise saw some ozone decline, but they noted the persistence of a high-pressure system not seen in this century—highs are linked to low ozone.)

By the end of April, as the real world failed to keep pace with NASA publicists, the agency retreated to the more modest chemically primed northern stratosphere. Instead of issuing a dire warning, NASA said that concern for northern ozone depletion was “enhanced.” Its spacecraft had found “large Arctic ozone depletion averted.”

Critics later accused NASA of using unrealistic predictions to screen its budget, which had gone to Congress on January 29. More likely, the agency had been trapped in another kind of vortex, the whirlpool of expectation that, if one

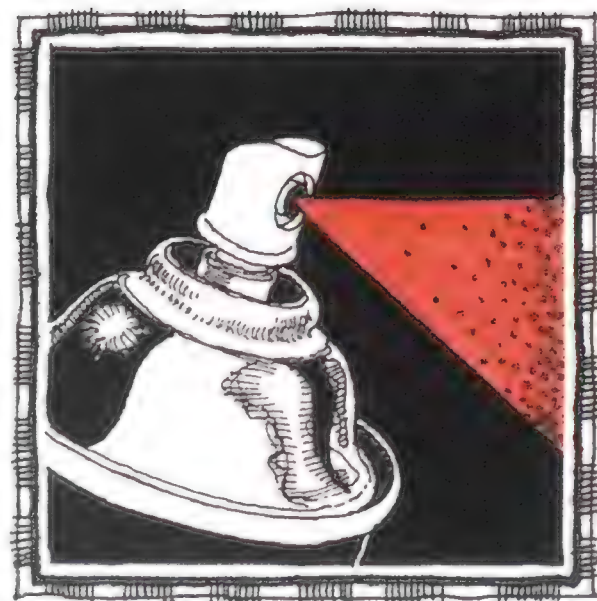
is looking for a hole, labors to find one. In the end, the spin toward chemical catastrophe did little for the agency's scientific credibility; indeed, some of the revisionism lamented by Brune may have sprouted from this breach of method.

Still, it was the discovery of an Antarctic ozone hole that made the business of limiting CFCs, under discussion since Rowland and Molina's 1974 paper, urgent good business. As Rowland points out, total chlorine in the atmosphere is about 4 parts per billion now, up by a factor of five since the 1950s. The whole airy apparatus is, as NASA likes to say, chemically primed to destroy ozone, and all because of industrial chemicals. Worry about the ozone led to the Montreal Protocol of 1987, in which 24 nations pledged to phase out CFC production. In 1990 they agreed to cease production and use by the year 2000.

Some observers see this as the end. Others see it as the beginning of a new research epoch. Ozone, it turns out, is linked to that other environmental problem, global warming. “Ozone has begun to enter the climate debate,” says Susan Solomon. “Ozone is a player in the greenhouse effect.” CFC substitutes, which also contain chlorine but have hydrogen atoms to make them chemically reactive in the lower atmosphere, must be looked over more closely. Some researchers note that, while the rate of CFC increase is dropping, it is still an increase. “The problem is not close to getting over,” says Solomon. “Without international controls it would have been much worse. The atmosphere is not magically healing itself. Policy is changing it.” And there is the matter of belief. “It is clear,” she says, “that there are people making statements about the degree of proof, motivations of scientists. Those of us who've worked very hard find that kind of representation very annoying.”

The reason the Arctic failed to perform seems to have been linked more to what people in the ozone trade call “dynamics,” meaning meteorolo-

William Brune cautions against scientific revisionism that downplays the threat to stratospheric ozone.



gy, than to chemistry. As NASA scientists were at some pains to point out in 1989 and 1992, the chemicals were there all right, waiting for the proper meteorology to make them sizzle. But invoking dynamics is now considered bad form. “There's no evidence to show that the overall trend has anything to do with anything but chlorine,” says Solomon. “I haven't seen any change in stratospheric dynamics that would cause the changes we see.”

James Angell, who has been studying the atmosphere and its ozone for the past 30 years for NOAA's air resources laboratories, is not one to be too sure of anything. Lanky and laid back, he seems incapable of viewing the atmosphere, which he has spent a lifetime reading, with anything like certitude. At the time of Rowland and Molina's 1974 paper, Angell says, “I was about the only one tracking ozone. At meetings Sherry Rowland often asked if I'd seen any depletion.” Until 1980, he says, there was little indication of anything, but then it dropped quickly.

“Why do we see such a sudden shift? All of a sudden—clunk. I wouldn't say this is natural variability,” he says. “I haven't seen anything like this since 1958. My guess is that this is new. Chlorine should produce something gradual.” He thinks that the Antarctic hole is probably a “chemical thing,” but characteristically he steers clear of certainty.

Angell is bemused by all of the natural intruders into the chemical arena of ozone destruction. He sees a strong correlation, for example, with the reversing stratospheric wind called the QBO—the quasi-biennial oscillation, which in the winter and spring of 1993 he found “just right for low ozone.” He frets about the apparent contributions of sunspot cycles—the stronger the ultraviolet emissions from the sun, the



STEVE TRESSLER

more ozone is created in the tropics—and of such air-sea perturbations as the El Niño, which alters the temperature structure over the Pacific in ways that can be read in weather around the world and, perhaps, in the amount of ozone over Antarctica. El Niños, he says, appear to follow volcanic eruptions, which have usually been followed by a reduction in stratospheric ozone. Particles from 1991's eruption of the Philippines' Mount Pinatubo, for example, appear to be providing a surface for ozone-chlorine reactions over the middle latitudes. On the other hand, the eruption of Indonesia's Mount Agung in the early 1960s had little discernible effect on ozone. "It will be interesting to see how ozone rebounds after the volcanic effects run out," Angell says.

His current chart indicates a global decrease in total ozone of about five percent, a figure that averages in the enormous depletions at the South Pole. In some areas, he finds ozone down one or ten percent, which he tentatively attributes to debris—the tiny particles called aerosols—spewed into the stratosphere by the Pinatubo eruption. But he doesn't understand why the volcano's effect has been so pronounced, and he would like data for a few years in which nature didn't intrude in these inscrutable ways.

Ozone has been a big part, but not all, of Jim Angell's long career. For his colleague Walter Komhyr, however, ozone—specifically ozone as measured by the world's 90 or so Dobson spectrophotometer stations—has always occupied center stage. Canadian-born and rather formal, Komhyr came to America following the International Geophysical Year (1957), hired by what is now NOAA because he had a reputation as an expert on measuring ozone with the Dobson instrument.

In 1990, Komhyr inadvertently became a heretic. He presented a paper that suggested a much stronger role for atmospheric dynamics in ozone depletion. Acknowledging that chemical attack by CFC-borne chlorine was certainly a factor in digging the Antarctic ozone hole, he argued that large-scale meteorological features—that is, dynamics—may have set the stage.

According to Komhyr, data for 21 of 27 years shows a strong correlation be-

tween sea-surface temperatures in the eastern equatorial Pacific during June, July, and August and the amount of ozone in the Antarctic stratosphere in October. When water temperatures are relatively colder, he finds higher ozone inside the vortex at the South Pole. When water temperatures are warmer, he finds lower ozone. "Assuming that we had no CFCs and we had conditions on earth like sea-surface temperatures that strengthened the polar vortex, would we see an ozone hole developing? My answer is: maybe yes," says Komhyr, although, he adds, the hole is clearly deepened by the presence of chlorine.

Because El Niños are manifested by a spreading of warm surface waters across the eastern Pacific, those phenomena likewise seem to become linked to Antarctic ozone. "If you have an El Niño during June, July, and August with peak temperatures," Komhyr says, "it will affect ozone in October. Whenever there is an El Niño in June, July, August, less ozone is transported poleward." It also goes the other way, Komhyr believes. "In 1988 there was a strong La Niña," he says, using the term given to the norm of colder surface waters and strong trade winds; "more than the normal amount of new ozone was transported from the tropics into the southern hemisphere between June and October. That year the polar vortex was weak and broke up early. The ensuing warm stratospheric temperatures rendered conditions in Antarctica unsuitable for prolonged destruction of ozone." Because of the early breakup of the polar vortex and stratospheric warming, Komhyr notes, mean monthly ozone

values over the South Pole increased from 152 Dobson units—the average October values for 1985, 1986, and 1987—to 245 Dobson units—a value not observed there since 1979.

In Komhyr's view, meteorology may be playing an important role in the depletion and replenishing of ozone. "Some very interesting things are happening here," he says. Certainly, his views have made his own life more interesting. His paper on sea-surface temperatures and ozone came, as one science reporter put it, when ozone was considered a done deal; there was not much interest in research that mused the settled



chemistry of ozone depletion or the funding thereof. After a couple of bounces, Komhyr's findings appeared in a Canadian journal.

Meanwhile, other signs that meteorological processes are major players in the waxing and waning of stratospheric ozone have come from two National Center for Atmospheric Research scientists, James Hurrell and Harry van Loon. Writing in the Belgian journal *Tellus*, they reported this year that the annual cycle of winds and pressures in the southern hemisphere changed markedly at about the same time that ozone watchers saw the first sharp drop in stratospheric ozone. What is called the semi-annual oscillation usually dominates the pressure patterns in the middle and high latitudes of the southern hemisphere. During the late 1970s and 1980s, however, these patterns altered, creating a generally lower pressure across the southern troposphere. This change had the effect of shoring up the



polar vortex, so that its seasonal breakup was delayed—thus setting up the crucible-like conditions in which the Antarctic ozone “hole” was first observed.

Komhyr still labors in the ozone vineyard, building ozonesondes and working on the data generated by the global Dobson network he helped create and calibrate. The ground truth he has developed for stratospheric ozone is the international standard and the ground truth for NASA’s satellite instruments measuring ozone. But his other ground truths, if that is what his meteorological correlations can be called, are viewed as apostasy, or dismissed with “Well, he’s not a chemist, you know.”

From the standpoint of identifying a problem, measuring it in the field, and forging findings into policy, the ozone depletion studies of the past 20 years may be in a class by themselves. And yet, the original question remains almost as pristinely unanswered as it was in 1974. The amount of ozone in



the stratosphere is only important if its depletion is accompanied by an increase in the amount of damaging ultraviolet radiation reaching the ground. *That* ground truth is not even close at hand. Research here has never had even subsistence support. The result: no one knows what the actual, long-term effects of a depleted ozone shield—and the presumed increase in ultraviolet-B at the surface—will be. This uncertainty hasn’t kept some researchers from attributing vile things to increased UV. The observed decline in many species of frogs, for example, has been tentatively attributed to such an increase,

even though some of the vanishing species live down on the rainforest floor, where little ultraviolet penetrates.

One rule of thumb is to double the percent of ozone loss in the stratosphere to calculate the radiation increase: a 10 percent ozone loss, in this model, produces a 20 percent increase in UV-B. Solomon says that you can see the UV-B rise when the Antarctic hole drifts over an instrument, and most scientists agree that the rule of thumb works pretty well for clear skies on a mid-summer day between about 10 a.m. and 2 p.m.

When the government entered the ozone trade seriously in the mid-1970s, a network of about 20 instruments was set up by NOAA, the National Institutes of Health, and Temple University. The idea was to obtain the first multi-year record of the amount of UV-B on the ground, then correlate it with ozone loss and the incidence of skin cancer in urban areas. The instruments were Robertson-Brewer radiometers—small, cylindrical, droid-looking devices about 10 inches high and topped by a quartz dome. Today, six or seven of these little fellows still sit in their Weather Service site, about as well-tended as the first Mrs. Rochester, and almost as mad. “They’re slowly dying,” says a NOAA researcher. “No calibration, no maintenance.” And thus far, no usable data.

The network’s first decade of data was put to work by National Institutes of Health epidemiologist Joseph Scotto in a 1988 *Science* paper that attempted to quantify the ultraviolet/skin cancer side of the ozone depletion equation. His article showed a decrease in ultraviolet during the period when, given a supposed decline in ozone, most scientists expected to see an increase. The meteorologists were bewildered by this counterintuitive result; the chemists, according to one scientist, were enraged. In fact, it appears to have been an honest error. “As near as I could tell, a calibration drop occurred about 1980,” explains NOAA’s John Deluisi. “They switched over to another calibration method and lost about four or five percent in the shift.”

Deluisi, a compact, serious man, believes that he and a helper might be able to rehabilitate the now useless 20 years of radiometer network data, and is scratching around for the several tens

of thousands of dollars it will require. He hopes to discern what the network did not. “For the period of the Scotto paper,” Deluisi says, “it’s like a two percent increase per decade. From 1978 to 1985, more like a 3.2 percent per decade increase. That’s what the R-B meters should have seen.” But they did not. “Is the ultraviolet increasing? Nobody knows. It has not been observed. We know the processes, but we have to verify them observationally.”

Peering out the window at the bright, snowbound Boulder day, he continues, “The problem with ultraviolet, if I go out there today and run ultraviolet and ozone I’ll get a strong correlation. But you start adding clouds and surface reflectance, and variability kills you if you want to determine a long-term trend.” He notes that the Canadians obtained data last year, a year of unusually low ozone, showing heightened ultraviolet at the surface. “I think it’s valid,” says Deluisi, “those guys are careful. But it looked to me like it was all last year. An anomalous year, with ozone low, ultraviolet high. Not a trend.”

To clarify his point, he draws a symmetrical hyperbolic curve on a chalkboard to represent the annual rise and fall of ultraviolet at the surface in the northern hemisphere. It rises from almost nothing in winter to a high curving maximum at the June solstice. “When you plot ozone changes on this curve,” he says, “it just makes the line rough instead of smooth, but the trend is not much affected. Clouds have a much larger effect.” So does pollution; ultraviolet has trouble penetrating Los Angeles smog.

When it does get through, the sun’s ultraviolet barrage has been clearly linked to the incidence of non-fatal kinds of skin cancer, although not conclusively to the more serious, often lethal kind called melanoma. The higher incidence of skin cancer among Australians, for example, a fair-skinned people living under a hot sun, has been well documented, and many Caucasians who spend much time in the tropics, where the ultraviolet dosage is highest, eventually develop some kind of skin cancer. There are compelling reasons for evolution to select for darker skin closer to the equator.

Sasha Madronich, a Slovenian-born

scientist at the National Center for Atmospheric Research, and Dutch colleague Frank de Gruijl have developed a table that shows how projected depletions of stratospheric ozone translate into changes in the incidence of skin cancer at various latitudes. Along the equator, they show a percentage point or two loss of ozone being accompanied by increases in the skin cancer dose of about the same magnitude, and a slightly larger increase in projected non-fatal skin cancers. At 45 degrees north latitude, ozone depletion of about six percent shows corresponding increases in skin cancer dosage of about eight percent, but increases in non-fatal skin cancer incidence ranging from 11 to 21 percent.

Still, it is a model. The skin cancer action spectra are from experiments with mice. The ultraviolet-B increase is based on what one should expect—what the derelict radiometer network might have seen but didn't—to happen to ultraviolet with x-amount of ozone depletion. Only the total ozone numbers come from observations.

Although an increase in skin cancer has a scary sound, much of the real fright has drained out of it. Even a 50 percent increase in a non-fatal disorder,

at a latitude where the incidence tends to be quite low anyway, does not alarm. In Britain, the projected decreases in ozone are expected to increase ultraviolet-B—and the risk of skin cancer—by about the same magnitude as a move from northern Scotland to the south of France. But how many Aberteenars would be deterred from moving to Provence? In the United States, where tobacco is said to contribute to some 400,000 deaths each year, adding a few thousand curable skin cancers would seem to be small change.

But what about those organisms that are unable to splash themselves with slime, or put on hats, or deploy parasols? The real biological consequences of any projected increase in ultraviolet B will almost certainly be in the realm of plants and lower animals.

One of the frightening scenarios invoked by William Brune in San Francisco is the destruction of the planktonic underpinnings of the oceanic food web. In what is generally regarded as very good work, marine biologists from the University of California at Santa Barbara have reported a decrease in productivity among some phytoplankton in the surface layers of Antarctica's marginal ice zone, below the drifting "hole" in stratospheric ozone. They concluded that the increased UV-B penetrating surface waters could cut annual primary productivity of plankton by two to four percent, but this occurs with-



in the context of an annual variability of 50 percent. In July, Canadian researchers announced that while ultraviolet may affect the growth of algae, it also affects the organisms that feed on it, resulting in a net increase in algae. Much quantifying remains to be done.

Martyn Caldwell of Utah State University in Logan published his first paper on ultraviolet radiation and plant life in 1968, before anyone had begun to fret about ozone-related radiation increases. Although biological impact is the heart of the ozone depletion problem, it has elicited perhaps one percent of the money hurled at the ozone-CFC question. And no wonder: plant studies are slow-moving, unexciting things usually done in greenhouses, or in controlled outdoor growing experiments. The most exciting piece of equipment is an ultraviolet lamp. There are no former spy planes, no pilots in spacesuits, no satellites; just botanists in denims, watching plants grow.

In a recent paper, Caldwell and colleague Stephan Flint summarized nearly 300 journal articles concerned with the terrestrial effects of increased UV-B. Most experiments were short term—few lasted more than a few months—and many involved plants in greenhouses and growing chambers, where UV-augmented light was employed without any provisions for cloudiness or other result-skewing effects. Longer-term studies showed scattered results. Some suggested that UV-B reduced growth, although the effect seemed to vanish during dry years. A three-year study of loblolly pine seedlings by Alan Teramura and Joe Sullivan of the University of Maryland found little immediate impact but indicated that there might be a cumulative adverse effect on growth over time.

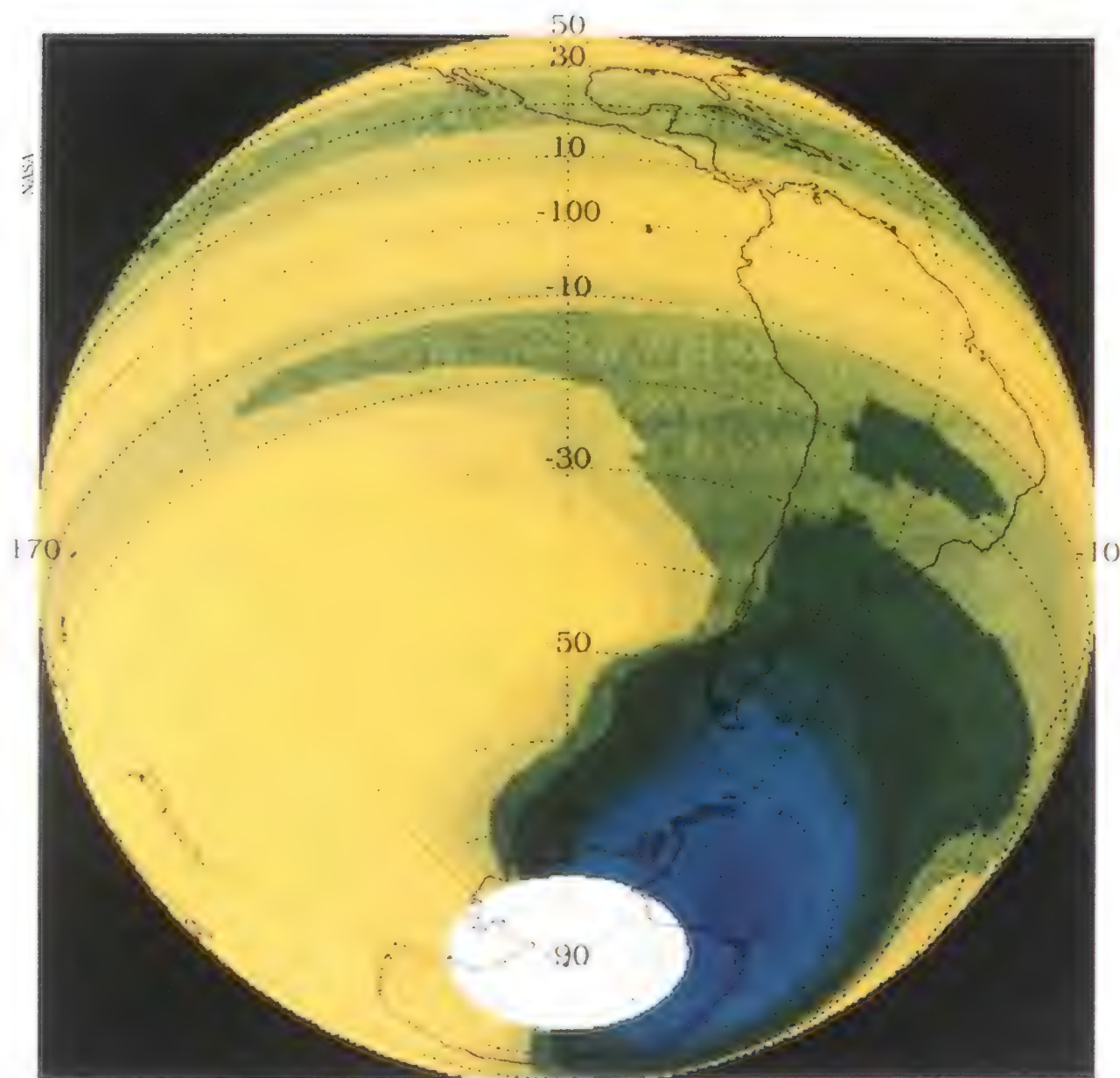
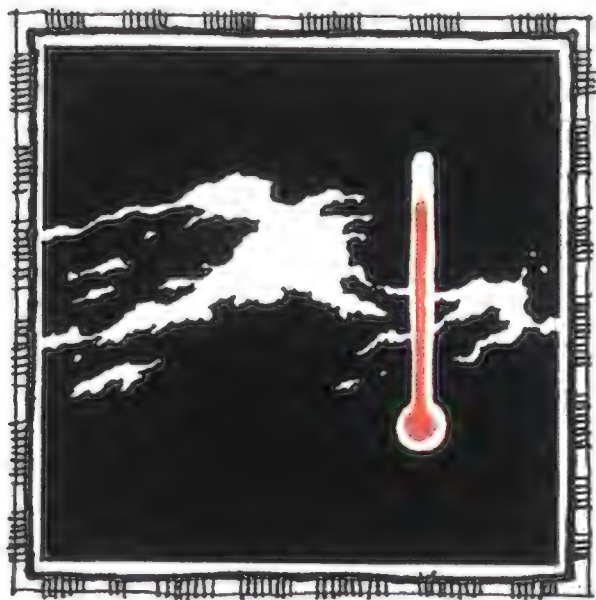
In 1986 Susan Solomon led an expedition to Antarctica to study ozone depletion there.



The problem, Caldwell explains, is that plants have a very complex relationship with the energy they receive from the sun—one that is not easily reproduced in a laboratory. “There are a lot of signals and communication with light,” he says. A high enough dose of UV-B appears to have destructive effects on individual plant cells, and whole plants may exhibit some reduction in photosynthesis and growth and show changes in shape and chemistry and reproduction. But not all changes impair plant fitness, he notes, and some may actually benefit the plant.

Perhaps the greatest imponderable is the degree to which plants adapt themselves to UV-B. “Certainly there is a lot of evidence of some adaptation,” says Caldwell. Some plants subjected to extra ultraviolet-B will alter their pigmentation or produce UV-absorbing sheaths for critical parts. But no one knows whether plants in high-ultraviolet areas like the tropics are better adapted than plants in Boston. A 20 percent change in the amount of UV-B striking a high-latitude plant could be devastating—and again, it could be harmless.

At the ecosystem level, Caldwell envisions changes in species composition, but he cannot say whether such changes would be good or bad. And his list of imponderables is impressive—extra UV-B could make some plants more attractive to certain insects, for example, but it could also make life harder for such nibblers. There is even some evidence that increased UV-B would tend to offset the increased growth stimulated by the rising carbon dioxide of another poorly understood environ-



mental crisis, global warming. To understand the real impact of depleted stratospheric ozone, such tricky equations must be solved.

In a belated new beginning, the Environmental Protection Agency is placing radiometers near a few large cities, and the Department of Agriculture is adding some in rural areas. This year NOAA began replacing the fossil radiometers installed 20 years ago with new, greatly improved ones. The aim is eventually to deploy a dozen of them. Curiously, the instruments are intended mainly to support the ultraviolet predictions NOAA's National Weather Service recently added to its forecasts. This politically correct addition suggests that a trend of rising UV-B has been detected; none has and it will take some years to see if one exists.

Most investigators believe that the chlorofluorocarbons already in the atmosphere will continue to seed the stratosphere with chlorine into the early part of the next century, and expect ozone to decline correspondingly, perhaps spurred along by particles from volcanic eruptions. But at some point, chlorine in the stratosphere will drop back to its earlier levels, and the pro-

Data generated by the Upper Atmosphere Research Satellite in the Antarctic spring of 1992 show ozone depletion over the southern polar region. Blue means low ozone; the white section immediately over the pole was not measured.

pective plume of ozone smoke will gradually replenish itself, as it has done for epochs. We and other life-forms, if we have adapted, will again adapt to a less frazzling sunbeam. As Susan Solomon puts it, “Nobody’s talking about Armageddon here.”

Indeed, after 20 years of Big Science, nobody knows what we are talking about here. If the chemists have saved humanity from ecological catastrophe, there is at present no way to verify it—no ground truth that would provide the reassurances that William Brune seemed to want in San Francisco. For all anyone knows, the ozone crisis will enter history not as a story of brilliant atmospheric chemistry, which it was, but as a complex cautionary tale, whose lessons we may or may not apply next time. *That*, in fact, is the one sure thing: there is going to be a next time. ➔

THE SMITHSONIAN TRAVELER



● TO REQUEST TOUR AND SEMINAR BROCHURES, CALL (202) 357-4700.
● TO REQUEST RESEARCH EXPEDITIONS BROCHURES, CALL (202) 287-3210.
● OR WRITE TO
STUDY TOURS & SEMINARS,
MRC 702, WASHINGTON, DC 20560.



INTERNATIONAL TOURS

Call or write for your FREE full-color Smithsonian International Land Tours catalog featuring both Study Tours and Seminars.

City Interludes (November-May) Off season sojourns in the world's great cities: London, Hong Kong, Lhasa (Tibet), Florence, Venice, Berlin, Kyoto, Prague, Vienna, St. Petersburg, Barcelona, Seville and Bermuda.

Splendors of New Zealand November 12-26.

NEW Three-Continent Christmas Voyage December 17-January 6: Europe, Africa and South America aboard the *Regina Renaissance*.

NEW Christmas in Provence December 19-30.

Christmas in Canterbury and New Year's Eve in London December 22-January 2.

South America (Cape Horn) Cruise January 3-28: Aboard the *Regina Renaissance*.

Yucatán Adventure January 4-16.

Patagonian Andes (Chile and Argentina) January 12-29.

NEW Papua New Guinea January 18-31.

NEW Vietnam and Cambodia Voyage January 19-February 12: Aboard the *Illiria*.

Indonesia Cruise January 27-February 12: Aboard the *Regina Renaissance*.

NEW Vietnam and Cambodia January 28-February 13.

Oaxaca Countryside February 3-13.

NEW Windward-Leeward Islands Caribbean Cruise February 5-15.

London Performing Arts February 6-16.

Copper Canyon (Mexico) February 11-18 or April 1-8.

NEW Belize and Tikal February 11-20.

Kenya-Tanzania February 19-March 7.

Among the Great Whales Cruise (Sea of Cortes) February 21-March 4.

Guatemala March 1-14.

NEW Orient Express in Malaysia March 3-15.

China Insights March 6-20.

Australia-New Zealand March 6-26.

NEW Chile Fjords Cruise March 8-22.

Island of Dominica March 9-17.

Alpine Snow Trains (Switzerland) March 9-20.

Costa Rica March 11-23.

Budapest Music March 14-23.



U.S. TOURS

Smithsonian "Anytime" Weekend (Washington, D.C.) Two-night package includes hotel and behind-the-scenes tour of the Smithsonian Castle building.

Smithsonian Holidays Special programs in Washington D.C. December 8-11, Williamsburg December 15-19, Santa Fe December 21-27 and New Orleans December 22-26.

Yellowstone in Snow February 11-18.

South Texas Birds February 11-19.

NEW Puerto Rico's Treasures February 18-28.

NEW Forgotten Florida (Apalachicola) March 19-27.

California Deserts March 20-26.

Savannah and Charleston March 24-30.

NEW Arizona History and Architecture (Phoenix and Tucson) March 25-April 1.

Hawaii Trails and Reefs (Kauai, Maui, Hawaii) March 25-April 5.

Springtime in San Antonio and Austin April 1-8.

Big Bend National Park April 10-18.

Smithsonian Treasures (Washington, D.C.) May: For Contributing Members.

NEW Connecticut Heritage May.

Maryland Homes, Gardens and Hunt Country May 1-7.



SEMINARS

American Antique Furniture (Washington, D.C.) January 6-10.

Egypt and Mesopotamia (Washington, D.C.) January 21-25.

Bali (Indonesia) February 8-19.

Winter Ecology (Jackson Hole, Wyoming) February 18-23.

Southwestern Culture and Cuisine (Santa Fe) February 21-26.

Florida Heritage (St. Augustine and Amelia Island) February 22-26.

Venetian Art (Washington, D.C.) March 4-8.

Wolf Tracking (Ely, Minnesota) March 4-10.

Bonaire (Netherlands Antilles) March 4-11.

Writers and Key West (Florida) March 11-15.

Philadelphia Art & Architecture March 18-22.

Interior Design (New York City) March 22-26.

In the Steps of Jefferson (Richmond, Virginia) April 20-23 or May 4-7.



ODYSSEY TOURS

Moderately-priced Tours (1994) Great Britain, Italy, Sicily-Malta, Greece, France, Greece-Hydra-Crete-Santorini-Rhodes-Turkey, Jordan-Israel, Portugal-Spain, Morocco, Belize-Honduras-Guatemala, Costa Rica, London-Amsterdam-Brussels-Paris, Prague-Budapest-Vienna-Salzburg, Scandinavia, India, U.S. National Parks, Arizona-Colorado and Washington, D.C. For an Odyssey brochure, call 1-800-932-8287.



RESEARCH EXPEDITIONS

Assist scientists and researchers in the field. For your free 1995 Research Expeditions catalog, call: (202) 287-3210 or write Smithsonian Research Expeditions, MRC 933, Washington, D.C. 20560.



Back to the Basics

It lacks the glamour of the World War II fighters, but the Stearman trainer has a wayward charm all its own

by Bill Marsano

Photographs by Eric Lars Bakke

It's late on a Friday afternoon in June at the airport in St. Francis, Kansas (population 2,000), which I think of a little grandly as my "home field." The sky is blue as a florist's cornflower, and it's full of Stearman biplanes.

This is my second visit to St. Francis. Two years ago a travel magazine suggested I make a low-level cross-country flight to write about what airline passengers seldom pay much attention to: the earth from above. To make the story come alive, I knew I'd need an airplane with real stage presence. Luck brought me St. Francis' airport, Robert Grace, and his dad's restored Stearman.

Grace and I took off for 10 days of open-cockpit pleasure, pointing southwest, destination unspecified. We met friendly people at little airports, followed wagon ruts along the Santa Fe Trail, and were chased along a runway by a small herd of antelope. Grace often en-



couraged me to fly the Stearman, and I did, a little: slow 360-degree turns, my first heart-stopping stalls. I have been Stearman-crazed ever since, and that's why I've come back for Grace's annual Stearman fly-in.

There are several biplane gatherings held each year. The biggest is at Galesburg, Illinois, which draws several dozen Stearmans from across the country. There's even one in England, honoring the thousands of Royal Air Force pilots who did catch-up training in the Stearman in the United States during World War II.

Fly-ins recall barnstorming days in ways big airshows, however wonderful, cannot. They are a step back in time: flocks of little airplanes come to roost in small towns, the pilots are heroes, the locals are agog. If there's a grass runway and clear skies, life is beguilingly close to perfect.

St Francis' wingfest has all of that and a little more. It has skydivers spilling from a Cessna 206—surely one of the



world's ugliest airplanes—aiming for the high school practice field, balloonists planning a pre-breakfast ascension, and a party for Grace's friends, colleagues, and fly-in volunteers.

But why Stearmans, especially?

Every summer Stearmans and other classy antiques come to cavort at Robert Grace's fly-in at St. Francis, Kansas, where mornings belong to hot-air balloons and afternoons are redolent of barbecue.

Of the many guides to an airplane's quality, one is quantity: weight of numbers usually suggests a thoroughbred. The Stearman certainly is that, yet it is also one of the least known airplanes of World War II.

Even ordinary earthbound folk know many big names from the Big One. Years of World War II anniversaries have shown new generations the C-47/DC-3, the Battle of Britain's elegant Spitfire and its nasty-looking opponent, Messerschmitt's Bf 109, the P-38 Lightning and P-47 Thunderbolt fighters, and the Great White shark of aerial combat, the P-51 Mustang.

But the Stearman biplane proves that time flies: it goes largely unrecognized





Their working days behind them, most Stearmans are in semi-retirement as beloved showpieces. Some display their owners' terms of endearment (below, left) and most are painted in blinding hues.



today despite its numbers (8,584 built, plus 1,762 more in parts) and its contribution as the primary trainer for more U.S. World War II pilots than all others (Ryan and Fairchild monoplanes and the Naval Aircraft Factory's N3Ns) combined. It probably holds the record for washing out cadets too.

Built mostly in the 1940s by Boeing's Stearman Division in Wichita, Kansas, the airplane was supposed to be called the Kaydet. That was a cover name, like Mustang and Thunderbolt for the P-51 and P-47, meant to conceal developmental progress evident in P-51D and P-47N. Nice try. Hardly anyone called them Kaydets and almost everyone called them Stearmans.

Navy aviation cadets, whose training mounts were a sunny yellow and alleged to make crosswind landings either thrilling or terrifying, gave it another name. Given a moment's inattention, a Stearman would ground-loop into the middle of next week. The Navy students



called it the Yellow Peril.

On the flightline it stood like a mighty Percheron. Nearly 10 feet high, some 25 feet long, spanning more than 32 feet and grossing 2,635 pounds, it towered over cadets. The cocky couldn't wait and the dubious, suddenly full of second thoughts about slipping the surly bonds of earth, could. Its top speed, the specifications claimed, was 125 to 135 mph (to which Dick Stevens, a former Navy Stearman instructor, says, "Sure—with a tailwind." Most agree on

about 87 knots, or 100 mph).

There's similar disagreement on crosswind landings. New Stearman pilots (and ground-loop victims) say the trainer is a bucking bronco on rollout. Old hands admit to a steep learning curve but say the Stearman isn't treacherous if you "fly it until it's chocked." But both prefer yielding, shock-absorbing grass strips to pavement.

The Stearman's success as a trainer seems to back the veterans' view. A trainer must challenge the student, not



lull him to sleep; it must punish error but not intimidate. The Stearman qualified on that basis, and also because it was cheap (starting at \$8,000), easily maintained, and, because it was built like a bridge, able to survive all aerobatics and most cadets. (Dick Stevens recalls cadets returning "with barbed wire and fence posts trailing behind,

with telephone wire wrapped around the wings, with a wingtip bashed in about three feet.")

In any case, the Navy wasn't averse to a little implied macho. Robert Taylor, one of many Hollywood stars who fought a celluloid war, was a real pilot, denied combat duty because of age. The Navy assigned him to transports



A St. Francis city park doubles as a drop zone for skydiver and fly-in organizer Robert Grace (above). Most of the city's residents turn out to schmooze with pilots and neighbors and admire the airplanes (left).

and training films; in one he tells new cadets, "When you can fly the Yellow Peril, and fly it well, any other plane is just a kite."

Today, many former cadets remember the Stearman fondly. One of them, describing himself to me as "this former Naval air person, this former public servant, this present happy private citizen," had been, at 18, the Navy's youngest aviator: George Herbert Walker Bush.

"The first plane I flew was the Stearman," he wrote me. "I was a little scared at first, but the plane was forgiving and I made it through. On my first night solo, I came in too low. I felt the tree-tops brush, gently brush, the bottom of my plane. I was lucky the wheels did not hook onto a limb and bring me down. The plane could ground loop—too easy could it ground loop—so we had to learn to avoid that. The Yellow Peril was safe for aerobatics, but I never really liked the Immelmans, the loops.... I particularly did not like spins, though once familiar with that you could recover nicely.

"If someone said, 'Your life depends on it: You must this minute solo in an N2S, SNV, SNJ, F4U or TBF'—all planes that I flew in the Navy—I would instantly choose the Stearman. It would forgive me my trespasses."

The basic Navy designation was N2S; the Army Air Corps used PT-13, -17, and -18. Most were built with 220-horse-



power seven-cylinder Continental radials, but many had Lycomings and a small batch got the Jacobs when other engines ran behind airframe production. Overwhelmingly they were primary trainers, but some were fitted for night and instrument training, and the Army, anticipating the Stearman's post-war career, had three "mosquito bombers"—PT-17Bs rigged for spraying pesticide. The Army, which ordered the first Stearmans in 1936, also got the last one delivered to the military (it's now in the Air Force Museum in Ohio), but the Navy had the last ones in service, which retired in 1948.

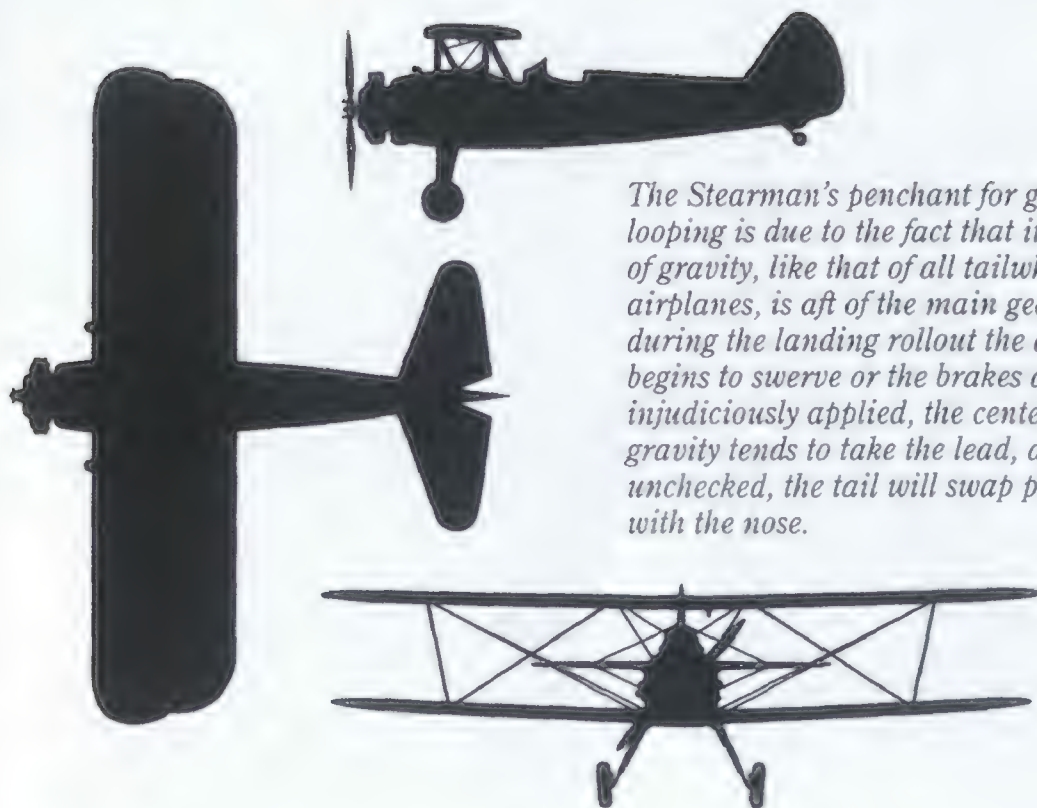
Stearmans never roused much public fervor during the war—after all, nobody bragged about a mere trainer. Cadets had to fly them to reach the sleek, sexy mounts, and hurry-up wartime training sparked few swoons. The Stearman was the airplane they left behind.



The Stearman's legendary strength is responsible for its long career as a trainer, aerobatic performer, and crop duster. George Mitchell of M&M Air Service in Beaumont, Texas (left), is proudest of "old Number 21," the company's first duster. "It made our business," he says.

But peace turned most of the hot ships into aluminum ingots. The wood-fabric-steel Stearmans weren't worth recycling, so the War Assets Board unloaded them as fast as possible, mostly to crop duster, sprayer, and seeder operators.

The slow, heavy biplane turned into an agricultural star. It was plentiful and it had a type certificate from the government. And it was ridiculously cheap, starting at about 10 cents on the dollar and descending rapidly. M&M Air Ser-



The Stearman's penchant for ground-looping is due to the fact that its center of gravity, like that of all tailwheel airplanes, is aft of the main gear. If during the landing rollout the airplane begins to swerve or the brakes are injudiciously applied, the center of gravity tends to take the lead, and, if unchecked, the tail will swap places with the nose.

Origin of the Species

Various Stearmans were produced both by Lloyd Stearman at Stearman Aircraft, Inc., and by Boeing's Stearman Aircraft Division. To add to the confusion, many stories written over the years use the names casually, in phrases like "Stearman-built." Which Stearman was seldom made clear. Some writers credit Lloyd as designer, but others demur (one goes so far as to say: "Lloyd Stearman actually had very little to do with the design of his most famous namesake").

All sources agree that the trainer derives from the X-70, built by the Stearman Aircraft Company as an Army Air Corps trainer in 1934. By then, Lloyd had left the company. The X-70 developed into the Model 73 and finally the Model 75—the Navy's N2S (-1 through -5) and the Army's PT-13, PT-17, and PT-18.

But where did the X-70 come from?

Deed Levy was a Stearman test pilot in the 1930s. In an article in *The Outfit*, published by the Stearman Restorers Association in Rockville, Maryland, he says Lloyd Stearman designed a trainer, the Model 6, to Navy specifications in 1930. It did not win a contract and was submitted to the Army the following year. The Army bought four, designated YPT-9s, and the company built a few more "Cloudbots" for the civilian market.

In 1933, Levy says, "the Army came up with a new specification and a new competition...." Levy had returned to Wichita that year to test two airplanes, one of them the Model 6, which by then

had some new features, such as a larger rudder of different shape and ailerons only on the lower wing, instead of both the upper and lower wings. "So...we started work. What features could we keep from the Model 6 and what improvements could we make?.... It wasn't possible to design a new airplane in only two months.... While improvements and changes were made, the basic Lloyd Stearman design of the Model 6 was kept and carried into the X-70...." A bigger engine improved climb performance, the landing gear was streamlined, high-pressure tires were added, the fuselage fairing was rounded, and the tail shape was changed. "The revision was started in late October and the X-70 was ready to fly by the end of December," Levy writes.

But famous trainer aside, Lloyd Stearman deserves his commemoration—at the Wichita elementary school named for him, in the National Aviation Hall of Fame in Dayton, Ohio, and in the fond if less formal memories of many pilots. Lloyd designed the New Swallow biplane and the famous Travel Air before founding his own company (Charles Lindbergh flew one of Lloyd's C-3Bs to survey early air routes). After World War II, he was involved in converting Stearmans from trainers to crop dusters, and at Lockheed (which he had briefly headed during the Depression) he worked on the variable-geometry wing for General Dynamics' F-111 fighter. He retired in 1968, but was working on a multi-purpose turbojet aircraft not long before his death in 1975.

vice, which eventually flew 34 Stearman crop dusters in Beaumont, Texas, may hold the bottom-dollar record. George F. Mitchell Jr., who runs M&M today, recalls, "we bid \$55.56 [each] and got 42."

Crop dusters mounted hoppers in the forward cockpit, added high-lift wings, and replaced the engines of most with surplus 450-hp Pratt & Whitney Wasp Juniors. "The 450 was the standard of our industry," Mitchell says. "We needed brute power for bigger loads, 1,000 or 1,200 pounds, and less turnaround time." Later, surplus 600-hp Pratt & Whitneys hauled even greater payloads.

Sturdy enough to save many cadets, Stearmans protected even more ag pilots, who flew them mercilessly. In their low-level, high-risk environment, many Stearmans terminated at Smoking Crater Airport, but their pilots usually walked or at least limped away intact.

In the '60s the Stearman was outmoded again, but only by something much like its own doughty self. The Grumman Ag-Cat, Mitchell says, "actually looked like a Stearman and had a lot of its good features, but corrected some problems. They put a canopy on it. None of us had ever flown enclosed—we're just country boys down here."

"But we still have old Number 21," Mitchell says, referring to M&M's first Stearman. "It made our business, so it's in museum condition and M&M colors—schoolbus yellow and delta green. And I like the Stearman. It offers serenity and peace of mind from just flying. You're not a technician operating hydraulics and electronics. You can feel the controls and breathe fresh air and fly by the seat of your pants."

Those homely virtues opened a third career: as a nostalgic mount for sunshine pilots. Converting crop dusters back to "two-holers" by stripping the ag gear and re-opening the front cockpit became a cottage industry in the late '60s. Ex-dusters, fully rebuilt, sold for \$8,000 to \$12,000—same as new, 25 years earlier. Today, Air Repair of Cleveland, Mississippi, and Mid-Continent Aircraft of Hayti, Missouri, specialize in Stearman restorations, as do some individual airframe-and-powerplant mechanics.

"Eight weeks or 2,500 man-hours,"

Revamped with 450-hp engines, some Stearmans are still at work today. Banners need a musclebound tow plane (right), and wingwalkers need a sturdy stage (below).



CHAD SLATTERY



JIM KOEHNICK/FAA



PHOTO OF GEORGE BUSH

In 1991, George Bush was reunited with the first Stearman he flew as a Navy cadet nearly 50 years earlier.

says Mike Cummins, an Air Repair A&P in charge of Stearman restorations. "Basically, we start with parts, a basket case. We dismantle the fuselage, get all the parts off of it, and then repair it. We go back to standard configuration—any extra appendages are removed, any damaged tube is replaced with original type and jig-fitted. The fuselage is sand-blasted and given two coats of epoxy paint. Then we re-linseed-oil it [to protect against internal corrosion] and start hanging parts back on. New wings are built—I wouldn't want to ride around on 50-year-old wood wings."

When the engine is hung on it, so is the price tag. Air Repair's president, Pete Jones, charges \$137,000 for a stock

Stearman and \$197,000 for a 450-hp Wasp Jr. conversion with inverted-flight systems and supplementary upper-wing ailerons for a snappier roll rate. Mid-Continent's president, Dick Reade, prices those models at \$135,000 and \$235,000 respectively, and he sells a few 600-hp Wasp models at "about \$260 to \$270,000." ("And we bought our first one for \$200," he says, sounding slightly amazed.)

As for the high speed claims that accompany the high prices, they are, well, claims. "On that subject," Grace says, "it's a case of 'everyone lies except me.' The stock Stearman is basically an 87-knot airplane, and I doubt the bigger engines will make them go 135 mph, except downhill."

One new Stearman owner, novelist Stephen Coonts, doesn't care. Fun, he says, "is not measured on an airspeed indicator." Coonts, a former Navy flier, trained in T-34 Mentors and T-2 Buckeyes; over Vietnam, he flew A-6 Intruder bombers (the inspiration for his best-selling *Flight of the Intruder*). "All of a sudden," he recalls, "when I'd begun making money from writing, I said: *Why not?* I had rented Cessna 172s and owned a Cessna 210. It's a good machine, but it wasn't fun to fly. You're always indoors. All my life I'd wanted an open cockpit. It's the difference between a car and a motorcycle."

Coonts' Stearman is a little rakish—300-hp Lycoming in a sleek cowl, yellow with a pin-striped speed streak, and a "naked floozie" called *The Cannibal Queen* painted on the fuselage. He flies it from his homes in Colorado and his



native West Virginia, where, he says, “a lot of people in these hills have never been up in any airplane, so as soon as I take the cockpit cover off there’s people all over, and everybody wants rides. So I spend two hours giving rides to Aunt Mabel and everybody else, and that’s the fun of it.”

There are still original Stearmans flying today. A few dusters soldier on, 40 years past their heyday. Four Stearmans tour the country for Red Baron Pizza, based in Marshall, Minnesota, promoting pies while performing aerobatics for charity; others tow banners or pose in TV commercials.

But most Stearman pilots sell rides or do other jobs just for gas money, or for larger callings. Leo Hrdlicka is skipping the St. Francis fly-in this year to fly from his Colorado home to Washington, D.C. towing a banner supporting the search for MIAs, his brother among them. A banner at one St. Francis fly-in read LUELLEN MARRY ME JOHN. It was short on poetry, but John’s blunt plea, floating behind a Stearman for all the world to see, was as good as a thousand violins, and Luellen fell over like a lodgepole pine.

Back at St. Francis, early Saturday morning a few hot-air balloonists manage to get airborne in the stiff prairie breeze, which quickly blasts them out of sight. The barbecuers are feverishly scrambling eggs for the breakfast crowd—families mostly, many of them

dropping a few bills in the donation box. The hangars are filled with skydivers packing chutes and with eager spectators, many of whom pay a few dollars for tandem jumps—that is, the neophytes get strapped to the veterans, they go up, they jump, they holler with excitement. (Before I knew what tandems were, I saw a chute coming down with a whole lot of legs sticking out and thought a cow had fallen out of an airplane.)

Around noon more airplanes arrive. More Stearmans, of course—eventually there will be 10—and restored ex-military observation planes, as well as sleek old Cessna 190s and 195s with radial engines, some homebuilts, two tiny Pitts Specials, and a blood-red Beech Staggerwing, the Jaguar XK-120 of biplanes. There is even an Alexander Eaglerock, a rare Colorado-built biplane, and a Navy-built N3N, which looks sort of Stearmanesque but is fat in the fuselage (“and don’t fly as well either,” say a couple of Stearman owners).

Pilots wearing “Ask Me About Stearman Rides” badges are offering 15 minutes for \$30, a steal. Finding Mike Baldwin’s Stearman at the repair hangar, I help him re-install his landing gear fair-

Navy Stearmans earned the sobriquet “Yellow Peril” from cadets it had bitten during training flights (above). Today, most Stearman veterans have an abiding affection for their first teacher.

ings and get a free ride. We get back in time for the competition. Sometimes it’s flour-bombing, sometimes short takeoffs, a Stearman specialty. A good pilot can get up in 300 feet.

This year it’s balloon-busting. Off in a gully, volunteers launch black helium balloons that pilots attack with their propellers. Last year’s champ popped seven; this year, seven is bottom gun, with eight pilots competing. That’s a lot of balloons. The launch chief, melting in the heat, says he’s lobbying for

a return to flour-bombing next year.

The party tonight is at the high school—some awards, some laughs, lots of barbecue. Everyone turns in early for tomorrow's hot-air balloon launch. But it doesn't happen: the winds are even higher than yesterday's, and they stay high, scattering the skydivers' two-plane formation dive, though Stearman rides continue without a hitch.

Things start winding down around mid-afternoon, and soon there are few left but Grace family members, friends,

and me. Grace takes me up for more aerobatics and lets me fly again before shipping me back toward Manhattan on an airplane that is much bigger and far less interesting.

I leave St. Francis well pleased. I've flown a Stearman again, made friends, and become convinced that the Stearman biplane is, collectively speaking, in good hands.

But what of the future? Private flying today is criminally expensive. Some airplanes fetch better prices used than

they did new, even ordinary ones without the character and romance of a Stearman, which itself is beyond the reach of most mortals. With an estimated 2,500 still flying, it should be a while before the Stearman suffers the sterile, static fate of rare classic cars: never used, just swapped among rich collectors as speculative investments.

I'd hate to see that happen. Stearmans are made to fly, and I like to think there will always be people who are made to fly them. —✈



How many Intre to change

Just one. The one that revolutionized the architecture of the automobile. The one that gives you more room, more power, and more safety features, like the available integrated child safety seat, that cars like Honda Accord and Toyota Camry

"The suspension is a common blend of what the segment wants and needs in roadworthiness and car control without presenting a bill for payment from the comfort account, with a balance of ride and handling that previously was available only in the best of imports."

—Motor Trend, January '93

"Through three-quarters of a year, we remain convinced that the overall size, comfort and convenience of this car, not to mention terrific performance, make it a winner."

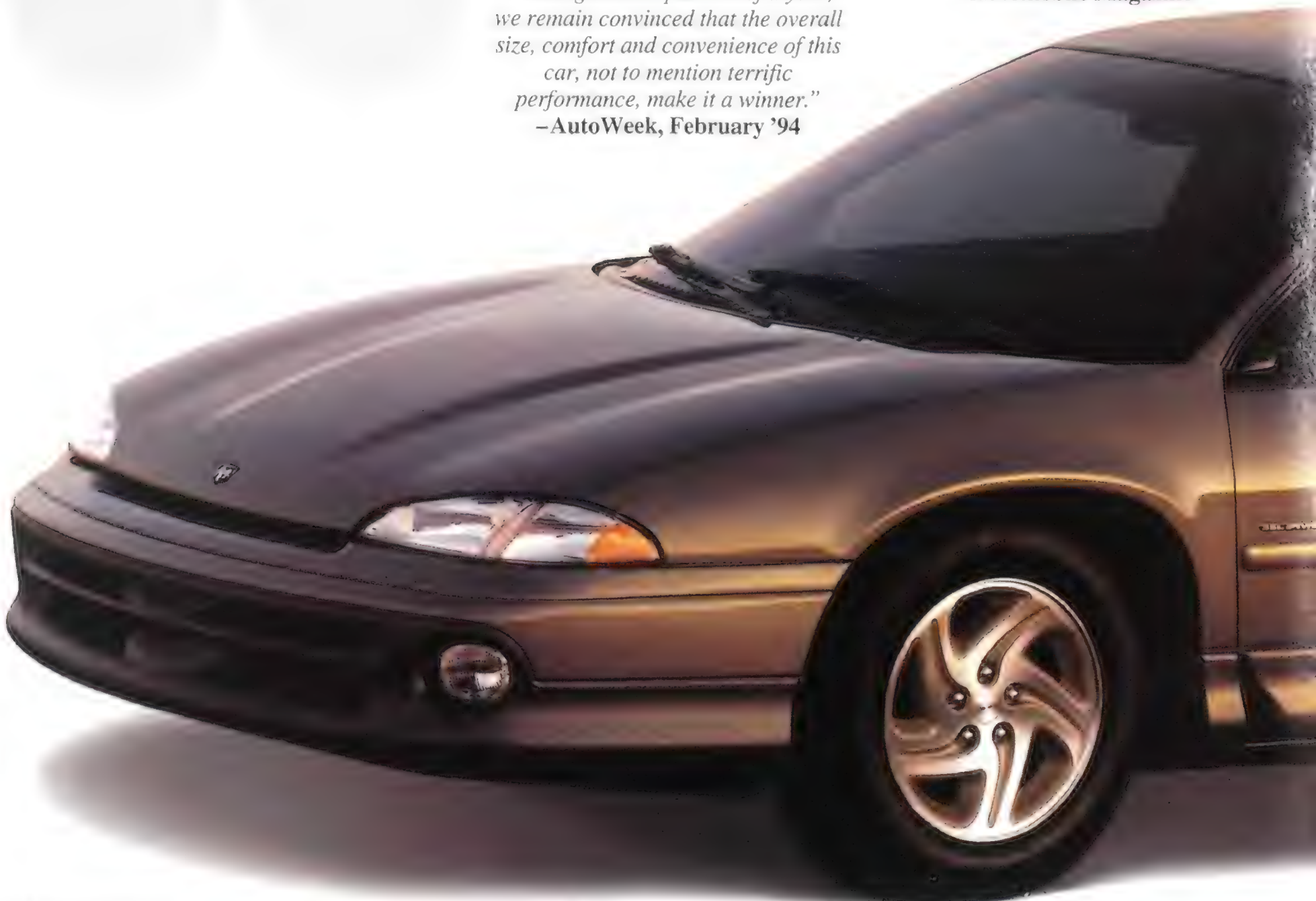
—AutoWeek, February '94

"The rock-solid reliability and overall value of the imports have made U.S. companies like Chrysler proverbial lambs amid a pack of wolves. Those days are over, thanks to cars like the Dodge Intrepid ES."

—Road & Track, June '94

*"Automobile of the Year, 1993,
All Star, 1994"*

—Automobile Magazine



Intrepid does it take everything?

can't match. The one with a new Customer One Care™ 3-year or 36,000-mile bumper-to-bumper warranty and 3/36 Roadside Assistance. The one that's changed a lot of minds about what a car can be. For more information, call 1-800-4-A-DODGE.*

"It's an American car that can hold its own in any company, on any kind of road."

—Automobile Magazine, January '93



"Best Bets, 1993, 1994"

—The Car Book



"Ten Best Cars, 1993, 1994"

—Car and Driver

"We emerged with a sense that this car represents an important milestone, not only for Dodge, but for the art of the American sedan in general."

—Popular Mechanics, April '93



"In many ways, Intrepid exceeds standards set by the best imports in their class."

*—Worth Magazine,
October/November '92*



Intrepid



The New Dodge
A Division of The Chrysler Corporation



BEAR ARMS

In the potholed forecourt of MiG headquarters, located in the first ring of the suburbs that encircle Moscow, three men sell bags of potatoes from a stripped-out military communications truck still painted army green. Office workers and engineers from what is arguably the world's most successful producer of supersonic fighters wait quietly in line to buy, one bag per person.

In the barely lit front lobby of the Vympel missile company, the only phone available to visitors is battered, and the

line is dead. At Gorki Park, the only flying prototype of the Buran, Russia's space shuttle, lies forlorn and unkempt. Just 15 miles away, in the once secret town of Zhukovsky, the Buran flight simulator, one of the most advanced in Russia, has the front end of a car protruding from its side as researchers try to convert the facility to civilian uses. At a jet engine test site 10 miles from Moscow, it looks as if work has stopped for the weekend. In fact, nothing has moved for months.

The chaos and decay that is Moscow

in 1994 washes up against the front doors of Russia's defense industry. Yet despite appearances, the industry is very much alive. Designers of Russian military aircraft and weapon systems are still organized into Soviet-style "bureaus," though they no longer have their sights set solely on the needs of the Red Air Force. Though you would hardly know it to visit them, today they are going after world markets.

Beginning in 1988, some of the design bureaus began to show up at airshows to learn how to market their

**Models (NATO):**

- Kh-31 (AS-17)
- R-77 (AA-12)
- Kh-25ML (AS-10)

SEEKERS: •active radar (Kh-31, R-77)
•laser (Kh-25ML)

INTELL: ramjet-powered Kh-31 (AS-17) being developed as air-to-air version for supersonic intercepts of AWACS aircraft; MiG-29 can be equipped with all.

The Russians may have lost the cold war, but in the global defense market, they could still win the battle.

by Bill Sweetman

The MiG-29 (here with four AA-8s and two -10s) is considered comparable to Western fighters, but Russia's new missiles may give it the edge.

wares more widely. Today the Russians are veterans of the air and defense show circuit from Europe to Asia, and their aim is not to push propaganda but to sell weapons so that they can pay their engineers in the only kind of money that anyone wants—the U.S. dollar.

To earn hard currency, the industry

has been quick to reverse government policy regarding the export of advanced weapons. The Soviets used to have two versions of every weapon: the standard weapon issued to frontline Soviet units, and a much simpler, less capable "monkey model," as the Russians call them, designed for wartime production but also built for export.

Now Russian industry is ready to sell the best, including weapons the Russian armed forces cannot afford itself. One of the most formidable is a new missile from the Vympel design bureau: the R-77. According to MiG general designer Rostislav Belyakov, the MiG company is offering the Vympel R-77 air-to-air missile (known as the RVV-AE for export) to air forces operating the MiG-29 as part of a package of modifications and updates to the fighter. Vympel has completed the development of the R-77, but Russian defense cuts have so far kept it from reaching production.

When the R-77 was unveiled in 1992, Western analysts nicknamed it AM-RAAMski because it seemed similar to the U.S. AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM). The weapons match up roughly in size and performance, and both carry a miniature radar—an "active" seeker—so that they can home on their targets without the aid of the radar on the fighter that fires the missile.

But some Western analysts have now concluded that the R-77 is better than the AMRAAM in some important respects. For one thing, the R-77 has more kinetic energy. The R-77 also has short, low-drag wings and Russian-invented

trellis-like tail surfaces, which create little drag but provide more maneuvering power than conventional fins. The result is that the R-77 is more maneuverable than the AMRAAM and may have the advantage in a head-on attack.

The U.S. Air Force has been studying a more agile version of the AMRAAM, known as the Phase 3. It would have had a flat-bottom body and ramjet propulsion, but it has been judged too heavy for the new Lockheed F-22 Advanced Tactical Fighter. The project office has gone back to the drawing board, and development will not start before 1997.

Britain's Ministry of Defense is likewise questioning its plan to buy AMRAAMs for the new Eurofighter EF2000 and has issued a requirement for a new missile with more energy at long range. British officials concede that the R-77 is the reason for rethinking the matter.

Also on the market is Vympel's R-27P, a version of a missile developed for the original MiG-29 and Su-27. It is the only known in-service air-to-air missile that homes on the signals from the target's radar. It was designed to attack such targets as the U.S. AWACS airborne-early-warning aircraft. The R-27P also threatens overconfident fighter pilots, because it can home in from a great distance without a telltale radar signal from the launch aircraft.

A former Pentagon missile expert who asked not to be identified says, "[The R-27P] is very worrying to the West because we don't know where it's deployed. You can't drive around with the radar on, because you don't want

to suck one of those in."

While the R-77 may be better only in some respects than its Western counterparts, Vympel's R-73 (Archer or AA-11 in NATO language) simply has no Western equivalent. "Archer surpasses anything that the West has fielded," comments the former Pentagon expert. "It's the driver for all Western designs...the King Kong of the within-visual-range fight."

The R-73 is a short-range air-to-air missile (AAM), like the U.S. AIM-9 Sidewinder. It was designed in the late 1970s and entered service in the mid-1980s; the AIM-9 dates back to 1952.

The R-73 bristles with no fewer than 20 aerodynamic surfaces and control devices, including canards, rudders, and two rocker arms wrapped around the missile's exhaust, each carrying a pair of heat-resistant tabs. The tabs vector the rocket motor's thrust in any direction, just as you can deflect the jet of a garden hose by placing your thumb over one side of the nozzle.

The nose is made of a special plastic that is transparent to shortwave infrared radiation. Inside the cone is a gimbaled optical seeker that can point at right angles to the missile's axis—"90 degrees off boresight" in missile language.

Even if the launch aircraft is pulling a hard turn and the R-73 launches into a 500-knot, 30-degree crosswind, the vectored-thrust missile can start to turn as soon as it leaves the launch rail. It flies a shorter path to the target, allowing less time for decoy flares or evasive action.

On the Su-27 and MiG-29, the pilot uses a helmet-mounted display to steer the R-73's seeker. The pilot moves his head until a crosshair is over the target. A tracker in the cockpit points the missile seeker in the same direction, and an audio signal tells the pilot it has locked on and is ready to fire.

The former Pentagon manager worries about this capability, particularly in the kind of ambiguous peacekeeping operation that has been set up over

Bosnia and Iraq. Rules of engagement can call for a U.S. aircraft to move alongside a suspected hostile aircraft in a classic intercept position. If the hostile opponent has an R-73 and a helmet sight, "he's only got to look at you and you're dead," says the manager.

To learn why Russia's R-73 is so much better than anything in the West, you have to go back to the early 1970s, when the Pentagon launched a test program called AIMVAL/ACEVAL (air intercept missile evaluation/air combat evaluation) to investigate missile design and tactics.

The Air Force and the Navy saw the need for a better short-range AAM, the Pentagon manager recalls, "but they couldn't agree on how to do it." The Navy backed a vectored-thrust missile called Agile, and the Air Force favored a smaller weapon called CLAAW (Close-range Air-to-Air Weapon). "Congress told the Air Force and Navy to do it together or not at all," the manager says.

But short-range AAMs do not always receive high priority in the Pentagon. "We still have to fight that battle every once in a while," the manager says. "People say that if we up the [kill probability] on the AMRAAM we'll never get within visual range." That is, the AMRAAM can win the battle before the enemy pilots can fire R-73s.

But in the real world, supersonic fighters in a head-on attack are committed to a visual-range fight. At supersonic closing speed they are not very maneuverable, so they cannot turn away before they are within visual range. "We run simulations and no matter how good we are, we're eventually going to merge and AMRAAM isn't any use," the manager says.

Nevertheless, in the 1970s the U.S. Air Force and U.S. Navy gave priority to the AMRAAM and worked on improved versions of the AIM-9. There was no sense of urgency: intelligence reports suggested that Soviet AAMs were at least a decade behind the West.

In fact, the Soviets were starting work on the new MiG-29 and Su-27, together with a new generation of AAMs. In retrospect, the Pentagon manager believes that they were well aware of the AIMVAL/ACEVAL reports. And not necessarily the unclassified versions. "Something may have been compro-



mised—I don't know. They may have thought that we were doing something like Agile, very quietly, but we weren't. Either way, we drove them to do Archer."

The West knew very little about the R-73, and it was only when the Berlin Wall started coming down in 1989 and Western agencies were able to examine East German MiG-29s that they finally appreciated the R-73 and, in particular, learned about its vectored-thrust rocket motor.

Western plans for short-range missiles were still in disarray. In 1985, the United States, Britain, and Germany had agreed to work together. But the U.S. Air Force decided that the German-British ASRAAM (Advanced Short-Range Air-to-Air Missile) would not meet its requirements, and the Air Force and Navy forged ahead with separate AIM-9 improvement programs.

Once again, Congress knocked the services' heads together. A new joint project office was formed in October 1990 to take over both Air Force and Navy AIM-9 update projects, and that office ended up killing both programs in 1991, partly because they were outclassed by the R-73.

The confusion and disarray extend to industry as well. When I submitted a list of basic questions about short-range AAMs to one of the major players in the U.S. missile industry in early 1992, the company's marketing manager responded: "Those are good questions. If you find the answers, tell us." Industry leaders knew what features the Pentagon liked: maneuverability, like the R-73; compact size, so more would fit in a cramped F-22 weapons bay; resistance to jamming and decoys. There was neither time nor money to do everything at once, but nobody knew where to commit resources first.

The joint office has now written a requirement for a missile called AIM-9X. If it works, it will begin to close the gap on the R-73's performance when it enters service—which will not be before 2000. Not even the new F-22 will have a helmet-mounted display to point the seeker at the target. They exist in laboratories and have been flight tested, but none has made it into production. "We beat the labs around mercilessly," remarks the former Pentagon manager, "but the problem is with the deci-

Missile Basics

Guided air-to-air missiles enable an aircraft to down an opponent beyond the range and line of fire of guns. Medium-range missiles, most of which can reach up to 60 miles under ideal conditions, are guided by radar. Most medium-range missiles in service use **semi-active seekers**, which sense radar energy reflected from the target. The aircraft that launches the missile has to illuminate the target long enough to provide a reflection for the missile to home to. Newer missiles just entering service employ **active seekers**, essentially miniature radar transmitters and receivers that can find the target themselves once they have been directed to its general area. In the real world, both adversaries are likely to be equipped with comparable missiles, which forces tactics that are radically different from those employed in a dogfight—the classic "furball."

Missiles employing radar to detect and track targets beyond the visual range of the pilot rely on their ability to lock on and fire before the opponent can. U.S. designers employ **stealth** to render a fighter invisible to radar until it is very close—and long after the stealthy aircraft has fired upon its opponent. Older, less stealthy fighters may use maneuvering to foil a missile. An aircraft might wait until the missile is quite close, then execute a very hard turn to evade it; missile designers strive for agility in the missile to counter evasion maneuvers. The rocket motor of a medium-range AAM

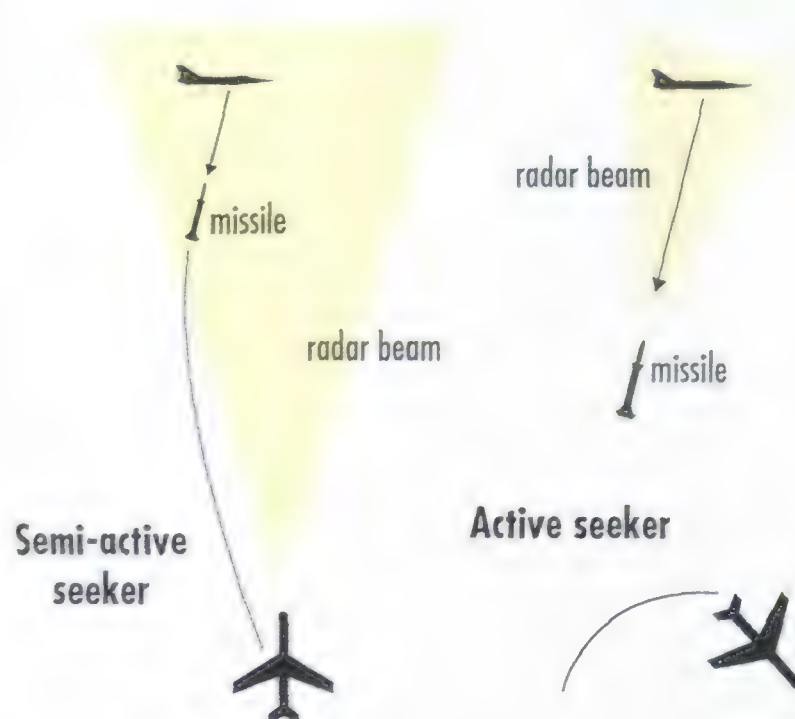
burns only for the first few seconds of the missile's flight, leaving the missile to coast the rest of the way. If the target takes evasive action, the missile has to maneuver to counter it; the target aircraft has power, while the missile has only a reserve of kinetic energy. The missile designer's aim is to preserve enough of that energy for maneuver.

Countermeasures, including electronic spoofing signals, might confuse an oncoming missile's seeker. **Decoys**, such as towed or ejectable emitters, give off a signal that can lure a missile off the target. Reflective **chaff**, usually a packet of thousands of silvery fiberglass threads, can be deployed to create a virtual "cloud" impenetrable by radar. But chaff is only useful against missiles coming from behind an aircraft.

The classic missile-versus-missile encounter is the head-on attack, with each aircraft hoping to get off the first shot. If both survive and close to within visual range, **short-range** missiles come into play. Smaller and more maneuverable than their long-range cousins, this category of missiles almost exclusively homes on the heat, or infrared energy, radiating from a target. **Infrared seekers** are optical devices that can see infrared wavelengths. Early versions required the launching aircraft to be almost directly behind the target in order to lock on because their seekers needed the hot metal of a jet exhaust nozzle to work. Most of today's missiles have more sensitive all-aspect seekers and can home on the hot gases in the target's exhaust plume.

With early missiles, a pilot had to maneuver so that the target fell inside a narrow cone centered on the attacker's nose—on **boresight**. This cone has expanded with time, and the seeker heads of the newest high off-boresight weapons such as the R-73 can turn as much as 90 degrees off the airplane's boresight.

Countermeasures include optical devices that dazzle the seeker's eye and flares that emit enough heat to distract the seeker from the target.





The bristling Su-27 Flanker and derivative models can fire missiles rearward, guiding them with a tail-stinger radar.

sion-makers." The Air Force and Navy have set tough specifications, which the Russian helmets probably could not meet, but it does not take a sophisticated helmet sight to drive an AAM seeker.

More worrisome, the R-73's thrust-vectoring system could endow it with a unique ability to engage targets be-

hind the fighter. The fighter pilot's classic attack position—the enemy's "six"—could become a deathtrap.

Vympel ended years of speculation early this year when it issued a brochure showing an R-73 being fired rearward from an Su-27 fighter. Two derivatives of the Su-27 feature a long tail "stinger" which is considered likely to house an aft-facing radar that could detect and track targets behind the aircraft.

Russian designers have been looking at rear-firing missiles for years. Soviet military transports all had tail gun turrets until the Antonov An-124, first

flown in 1982. In place of a turret, it had a gray composite tailcone that looked exactly like a fighter's radome. Observers were quick to speculate that in wartime, the An-124 would have a rear-looking radar and rear-firing missiles.

Western pilots have been skeptical about rear defense schemes, usually because they require the missile to fly forward off the rail, then pull a tight 180-degree turn toward the target's last known location. Only then does the seeker lock on to the target. The Pentagon manager says: "It's a bit like putting a pit bull in a gunny sack, shaking him around, and then pulling the sack off. He's probably going to bite the first thing he sees." If the first aircraft in sight is not the target, the nearest alternatives are the shooter's wingman and the shooter himself.

But if the missile is fired to the rear, it can lock onto the target before launch in the normal way, and its time of flight will be just as brief as that of the attacker's missile. Only the Russian designers know how to do this. The missile sits on its pylon moving tail-first through the air. After it is fired, it must accelerate in an initially negative relative wind through zero airspeed to its normal forward flight velocity. Unless the missile has a vectored-thrust motor it is likely to tumble end over end (think of a *drunk* pit bull coming out of a sack). And the R-73 is the only missile in service or under development that has vectored thrust (see "The Shoot-to-the-Rear Problem," p. 59).

But another argument says that a Russian success with the over-the-shoulder shot will put more emphasis on tactics and stealth. If the rear-firing missile negates the classic stern attack, winning the head-on, medium-range battle becomes even more important. The new F-22 is designed to win the medium-range duel and stay out of the visual-range furball. In the opening stages of a battle, the F-22's first big advantage is stealth, which allows it to see the adversary and fire before the adversary can detect it. Its second key feature is that it is more maneuverable at supersonic speeds than any other fighter, so it can break off after launching its missiles and disengage before it runs into the visual fight. But stealth and supersonic maneuverability make the F-



MODEL: R-73
(detail view)
NATO: AA-11
Archer
INTELL: movable
vanes in exhaust
nozzle provide steer-
ing; entered service
in late 1980s;
currently available
for export MiG-29
package; no known
Western equal.

BILL SWETMAN (2)

launched weapons in quantity. The Kh-58Yu (AS-11 Kilter) has no direct Western counterpart: it is a supersonic anti-radar missile, bigger and faster than the U.S. High-Speed Anti-Radiation Missile (HARM). "It was designed to go after Nike, Hawk, Improved Hawk and Patriot [U.S. air-defense missiles]," says Seleznyov. "The big difference is that you are not dealing with a short-range weapon—this has a range of 120 to 200 kilometers [75 to 125 miles]." A Kilter fired from over Sarajevo could knock out an AWACS over the Adriatic.

Raduga's other current tactical missile is the Kh-59M Ovod (Hornet), known in the West as the AS-18, a long-range missile guided by a TV camera and a data link, enabling the weapon operator to aim the missile while the aircraft stays well clear of defenses. The missile will hit the target within two or three meters of the aim point, says Seleznyov. The Kh-59M's closest Western equivalent is the McDonnell Douglas AGM-84D SLAM, but whereas the Ovod has been in full production since 1986, the SLAM went into only limited production, and did not enter service until 1990.

Raduga also makes the 8M30 Moskit anti-shiping missile, known in the West as the SS-N-22 Sunburn. A report that the Ukraine had sold eight Moskits to Iran caused alarm in the U.S. Navy; the Navy does not know if its defensive weapons will work against the Moskit and has no sure way of finding out. The Moskit is carried by many Russian warships, but Raduga has also designed an air-launched version, the Kh-41. Seleznyov says that lack of money has

22 big and expensive, and costs and declining budgets have slowed the program down: the F-22 will not be in service until at least 2003.

The air-to-air battle is not the only arena that concerns planners. (A grim joke in European military circles in the late 1970s had two Soviet tank commanders sitting at a cafe on the Champs Elysees, watching the Red Army's victory parade. "What a pity," says one, "that we lost the war in the air.") Smart weapons were stars in the Gulf war, helping to disable Iraq's military long before a potentially bloody ground offensive had to be launched. What is not entirely appreciated is that weapons equivalent or superior to those are now readily available from Russia.

Secrecy still complicates the task of identifying all the different weapons in the former Soviet arsenal. The Soviets hid their smart air-to-surface weapons even better than their AAMs. A reading of the unclassified literature in the early 1980s would suggest (quite wrongly) that most Soviet fighter-bombers were armed with dumb bombs and unguided rockets. The only Soviet tactical air-to-surface missile to have been identified was the Zvezda Kh-23, known to the West as the AS-7 Kerry.

By the mid-1980s the Kh-23 was obsolete, and the Soviet Union had fielded a full range of air-to-surface missiles and other air-launched weapons. These have been gradually declassified since the late 1980s, but knowledge in this area remains patchy, which is why a display of in-service Russian munitions unveiled at Kubinka air base last April

represented a unique find. Many of these weapons still come from the Zvezda design bureau.

The Zvezda Kh-25 is the equivalent of the U.S. Maverick, a TV- and laser-guided missile. The Kh-25ML (AS-10 Karen) is laser-guided, while the Kh-25MP (AS-12 Kegler) is an anti-radar weapon. Zvezda produces the Kh-29L and Kh-29T (AS-14 Kedge), which are, respectively, laser-guided and TV-guided missiles about twice the size of the Kh-25. They have no direct equivalent in the U.S. The organization's latest known product is the Kh-31 (AS-17 Krypton), a high-speed anti-radar missile designed to attack the AWACS at long range.

Zvezda's designers declined to be interviewed, but Igor S. Seleznyov, general designer of the Raduga bureau, discussed his products openly. Raduga has two principal types of tactical air-



MODEL: Vympel R-77
NATO: AA-12 (nick-
name: "AMRAAMski")
SEEKER: active
radar
INTELL: "trellis"
surfaces on tail, also
used on ballistic
missiles (e.g., SS-
20), offer high ma-
neuverability with
low drag; exported
as RVV-AE, part of
MiG-29 package;
production not yet
ordered in Russia.



MODEL: Raduga Kh-58Yu
NATO: AS-11 Kilter
SEEKER: passive
INTELL: long-range air-to-surface anti-radar missile; designed to knock out NATO ground-based missile radar (Patriot, etc.); MiG-25 Foxbat equipped; closest U.S. equivalent is AGM-88 HARM.

BILL SWETMAN (2)



MODEL: Raduga Kh-59M
NATO: AS-18 Kingpost (or Kazoo)
SEEKER: optical TV
INTELL: solid booster, turbojet sustainer engine; long-range (100 miles) standoff attack missile; produced since 1986; similar in capability to U.S. SLAM attack missile used in Gulf war.

kept it from being tested.

Most U.S. Navy ships are fitted with Phalanx radar-controlled guns, which were designed to shoot down older, subsonic sea-skimming missiles. Moskit has a rocket/ramjet engine: a solid rocket motor boosts it off the ship, but when the solid propellant has burned away it opens an air passage, and the engine becomes a more efficient air-breathing ramjet. Such engines have been studied and occasionally used in the West, but Russia's Bondaryuk (now called Plamya) bureau first developed them in the mid-1960s and has steadily refined them.

The ramjet gives the Moskit tremendous speed. It cruises at Mach 2.5, or 1,900 mph, only tens of feet off the water. The difference between the maximum effective range of the Phalanx and the Moskit's impact gives the gun a window of about one second. Can the Pha-

lanx shoot a Moskit down?

The only way to find out is to use a target that replicates the Moskit's speed and maneuverability (in theory, says Seleznyov, a supersonic missile can pull 10 to 11 Gs). Unfortunately, the United States lacks the Russians' rocket/ramjet technology: the AQM-127, a rocket/ramjet target, was canceled in the budget cuts of the mid-1980s.

After the breakup of the Soviet Union, the U.S. Navy attempted to buy a batch of Moskits. It was rebuffed. "We understood," remarks Seleznyov, "that you wanted to get knowledge of how to shoot it down."

Are Russian performance claims valid? Seleznyov's comments are illuminating: he points out that one important difference between Russian and Western missile development is that Russian designers put more effort into "hardware-in-the-loop simulation," in which

the missile's seeker, guidance system, and controls are tested together on a specially designed ground rig. Seleznyov says that Raduga's simulated test facilities have no equivalents.

"Most of our information comes not from live firings but from simulation," says Seleznyov. Raduga does not test-fire a missile until the simulation shows that it is almost certain to work every time. One missile, he recalls with some pride, even hit its target after one of the folding fins failed to deploy. Raduga, says Seleznyov, has had one or two test programs in which every firing was successful—something that Western designers can only dream of.

Russian weapon designers have also benefited from combat experience: Afghanistan was a testing ground for Russian aircraft and weapons. A special unit called Rhombus was formed from test pilots, engineers, and support crews from the design bureaus. Rhombus used both standard and experimental weapons in combat, carefully measuring and evaluating their lethality and accuracy.

Even if Russian weapons are both more capable and better tested than many people thought, it might be argued that the differences are academic as long as the U.S. does not plan to fight the Russians. Today's worst-case Pentagon scenario is two "major regional conflicts" similar to Desert Storm. The impact of new-generation Russian equipment will depend on where and how it has been exported—and how it is used.

Russian industry is learning that life in the arms bazaar is nasty and brutish. An *Economist* report points out that Russia's share of a shrinking global arms market has shriveled from 32 percent in 1989 to only nine percent last year. "We have learned that the Western world opposes the selling of MiGs," comments Belyakov, accusing the West of "using any means, including prohibited means" to interfere. The Russians are not being singled out for dirty tricks: it is just that the warplane business, which makes *Mortal Kombat* look like the *Teddy Bears' Picnic* at the best of times, is deep in recession, and the people at British Aerospace, Dassault, Lockheed, and McDonnell Douglas are hungry.

Mikoyan pitched the MiG-29 very hard in Finland; the Finns bought F/A-18s. At one point the Swiss announced that they were looking at MiG-29s; they fell into the F/A-18 camp as well. Malaysia ordered MiG-29s, and both Western and Russian observers were somewhat surprised when in early June a contract for 20 was signed, the first Russian sale of combat aircraft in open competition with Western fighters. Malaysia will get its first aircraft next year.

The Soviet Union's record has been part of Russia's sales problem. The history of modern air warfare is littered with the smoking remains of Soviet-equipped air forces that challenged Western or Israeli weapons and tactics. Saddam Hussein's Iraq was following the tradition set by Egypt, Syria, and (in two engagements over the Mediterranean) Libya. History suggests that Russian-equipped foreign forces are paper tigers, formidable in numbers but ineffective.

A closer look reveals that now-abandoned Soviet military and political doctrine was a major factor in their weakness. The Soviets harbored fears that foreigners could never be trusted to keep the Soviet Union's military secrets. What seemed to be the latest aircraft were usually the stripped-down "monkey models" or older versions.

The phrase "monkey model" itself is a clue to another flaw in Soviet export policy: a robust racism that led to the

A Better Bomb

The F-117 stealth fighter's principal weapon in the Gulf war was the GBU-27, a laser-guided bomb with a specially designed "penetrator" warhead that can pierce many feet of concrete before exploding. This weapon has one drawback: to hit its target at the best angle and speed for penetration, it has to be released from 10,000 feet or more directly above the target. Because it is essentially a simple gravity bomb, it relies on the time of drop to achieve the speed it requires to penetrate a hard target. Such an approach leaves the

attacker so vulnerable to defenses that only the very survivable F-117 carries the GBU-27.

Russia's boosted penetrator, the BeTAB-500SchP, has been in service for several years but had never been seen by the Western press until last April. A parachute in the tail slows the weapon after release and lowers it into the ideal nose-down attitude before a rocket booster powers it to impact.

The weapon can be fitted with a laser guidance kit in the nose, but a former Sukhoi engineer remarks that it is so accurate and lethal that laser guidance is seldom used.



BILL SWEETMAN

The Shoot-to-the-Rear Problem

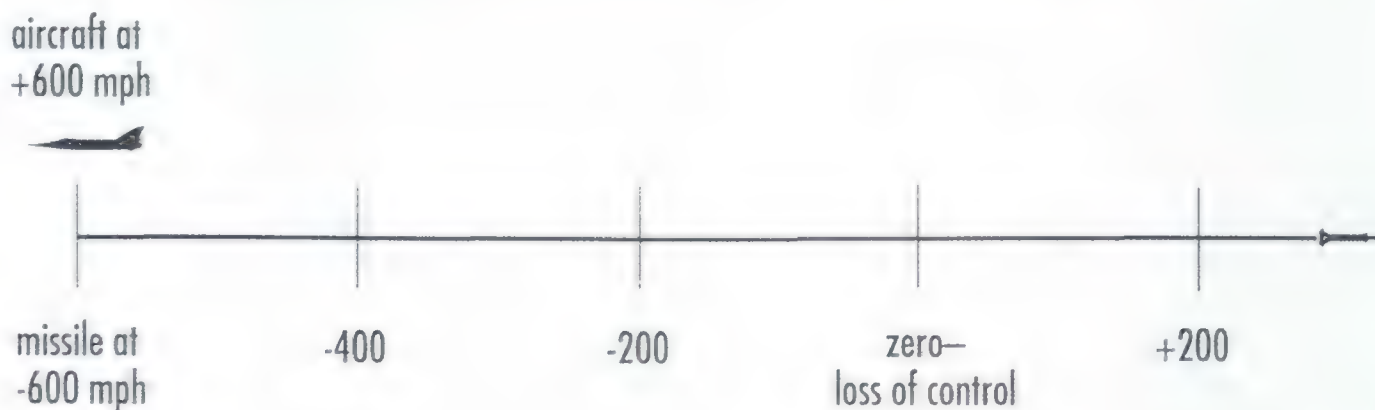
Almost all missiles rely on steerable fins to control their direction of flight. Like the wings on an airplane, fins need airflow over their surfaces in order to exert any control force on the missile.

A missile fired backward from an aircraft flying at 600 mph has an initial negative velocity of 600 mph. For the first part of its flight, therefore, the missile is as unstable as a dart thrown tail first and all its control laws are reversed: a control surface movement that would turn it left in forward flight turns it to the right instead (if the

surfaces are mounted traditionally, near the missile's tail).

As it accelerates to the rear, its negative velocity drops rapidly until at some point, the missile passes through zero airspeed. Airflow over its control surfaces drops to zero and they are unable to control the

missile and prevent it from tumbling. If the missile can make it through this point and gain positive velocity, it flies conventionally. By designing rocket motors with nozzles that steer the missile, the Russians have solved the problem of control in this situation.



assumption that Third World pilots were inept and merited only the most cursory training. In 1973 a group of pilots from Bangladesh were trained to fly the MiG-21. Later, one of them complained to Britain's *Flight International* magazine that they were given no combat training at all until they demanded it. Then, he said, they were given a minimal air combat course, including "suicidally indecisive" tactics. Ironically, the trainees, former Pakistan Air Force pilots, were all combat veterans. Their instructors were not.

When the Israeli Air Force shot down 85 Syrian MiGs and Sukhois over Lebanon in 1982, losing only two aircraft to ground fire, they did not ascribe their victory to technical superiority. "The [Syrian] pilots behaved as if they knew they were going to be shot down...and not how to prevent it, or how to shoot us down," an Israeli Air Force officer commented in a 1982 interview with *Flight International*. "They could have flown the best fighters in the world, but if they flew the way they were flying, we would have shot them down in exactly the same way."

A former U.S. Navy pilot helped study head-up-display-camera footage taken from aircraft downed during aerial combat in 1982. Later, he recalled that the G meters never showed more than 2.5 Gs in any combat he saw, suggesting that most of the victims never even knew they were under attack.

Desert Storm experience is hardly significant. The Iraqi air force flew mere dozens of sorties per day against hundreds of U.S. and allied missions. The forces in the air were so disparate that no amount of individual prowess on the part of Iraqi pilots, or performance in their aircraft, could have affected the outcome.

Soviet aircraft are also said to need frequent maintenance. The supply of spares, users have said, is so bad that some aircraft become "hangar queens," cannibalized to keep others flying. But this is not a design fault; rather it's a reflection of the way the Soviets operated their own aircraft and the way they were exported.

Western air forces expected their fighter maintenance organizations to perform complex tests and repairs on the base; the Russians did not. If any

component failed its basic functional tests on the aircraft, it was removed, replaced, and shipped back to the Soviet Union to be rebuilt. This worked well enough for the thousands of aircraft within the Warsaw Pact countries, but it was much less efficient for dozens of aircraft in the Middle East or Africa.

Soviet military aircraft were exported by Aviaexport, part of the Ministry of Aircraft Production, rather than by the bureaus. Aviaexport people received credit for selling aircraft, not spares. Sergei Sikorsky, a United Technologies vice president and a longtime observer of Soviet aviation, noted a pattern: "The Aviaexport people would always sell another aircraft rather than the necessary amount of spares. A year or two later, when the customer needed spares and tried to get them, they would all be committed [for domestic use] under the five-year plan."

Belyakov of MiG describes early sales attempts as "a bought education." Some lessons the Russians have learned are nothing new to the West but revolutionary in Russia. Belyakov acknowledges that "we have not had this kind of experience." Particularly in Southeast Asia, "there are different groups which support the prime minister, some which follow the Ministry of Defense, and some which are close to the royal family. You can't understand which group you can make a deal with.

"We think it is important to have direct contacts with the customer at all stages of the life cycle of the aircraft," says Belyakov, "including the training of the pilots and engineering person-

nel." Yakovlev general designer Alexander Dondukov remarks that "we have recognized that market analysis is no less important than the actual technical development of the aircraft."

MiG has formed a subsidiary called MiG-Service to provide training and support for customers. MiG has also established a joint venture with Germany's Deutsche Aerospace (DASA) to support the MiG-29s that reunified Germany inherited from the former Democratic Republic and has teamed with India's Hindustan Aeronautics Limited (HAL) to support Malaysia's MiG-29s, help train Malaysian pilots, and to modernize MiG-21s for India and other air forces.

Belyakov is looking for a partner to help provide the much improved MiG-29M with more fuel capacity and a Western-style "glass cockpit" of video screens to replace gauges. "We are ready to find Western investors to help us to complete the flight tests and jointly market the aircraft for export," he says.

Germany could be a logical partner, Belyakov believes, although DASA—heavily committed to the new MiG-29-size Eurofighter EF2000—does not see it that way. "We keep telling them that they only just flew their aircraft, they will deliver it by the end of the century, and it is even now inferior to the MiG-29." The Germans, he says, don't

Low radar visibility in a head-on encounter gives this stealthy U.S. Air Force F-22 an initial advantage over a missile threat.

BILL SWEETMAN



MODEL: laser-guided bomb
SEEKER: semi-active laser
INTELL: explosive charge of 500 kilograms (1,100 pounds); similar in appearance and capability to U.S. Paveway.

want to listen. "I tell them: 'Sooner or later, your taxpayers will tear you into pieces.'" As is apparent from such insights, when it comes to global markets Belyakov is a fast learner.

Comparing the -29M and the EF2000, Belyakov simply says, "I don't know of any areas where [the MiG] is inferior"—a choice of words that serves as yet another indication that he can talk the talk of the arms market. "They will

probably be able to deliver a weapon system of good performance if the Americans will let them have AMRAAM. Without AMRAAM it's very different." The new MiG-29M, of course, will have the excellent R-77, once it enters production, and the world-beater R-73.

Belyakov may have confidence in his company's products, but the significance of the truckload of potatoes outside his door is that the state no longer

isolates his organization from the problems of Russia as a whole—Mikoyan will have to scramble along with everyone else. And whether one looks at politics, economics, or infrastructure, the problems of Russia are grave indeed. But the Russians *are* learning, and if their industry survives through successful exports, the West may face some unexpectedly well-armed opponents in the years to come. —

ERIC SCHULZINGER/LOCKHEED



A TRIP

KEEP THIS IN SIGHT
PASS BEARER
TO CITY OF MOON
AND PALACE OF THE
MAN IN THE MOON
WHEN ON
TRIP TO THE MOON



NASM, TAG AND PIN, RANDY LEE KIMAN COLLECTION

From the richly colored and detailed lobby of a futuristic spaceport, would-be space travelers move down a long corridor to a dock on the edge of Earth. Here, in preparation for their journey, the travelers learn how the gravitational pull of Earth will be overcome, how oxygen is preserved in the atmosphere they'll encounter, and the very secrets of spaceflight itself. Then the travelers climb aboard the great ship. It is night, and throughout the heavens countless stars glisten. Far off in space shines a crescent moon.

A surrealistic dream? An illusion? It was both, and more. This was the original concept for "A Trip to the Moon," an attraction at the Pan-American

Exposition in Buffalo, New York. The most remarkable thing was that the year was 1901.

Save for some architectural changes, the basic concepts of the attraction did materialize. Frederic Thompson's "A Trip to the Moon" was one of the great sensations of the exposition, held from May to November of that year. It was the first and most widely publicized of the attractions erected on the exposition's midway—the family amusement area. Thompson spared no expense creating an elaborate illusion of a lunar voyage, complete with a journey from Earth full of special effects and an exotic lunar landscape populated with fantastically costumed moon dwellers. The return to Earth was less elaborate—a

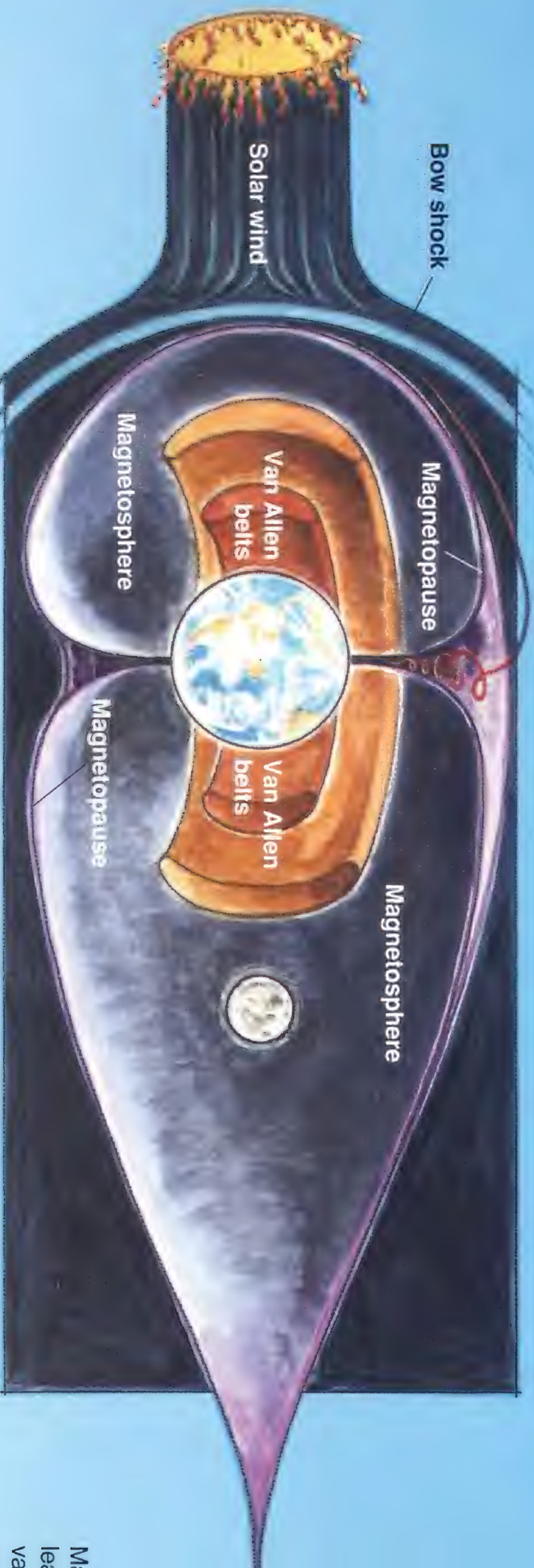
simple rope ladder leading to the exit.

Thompson obviously had not striven for scientific accuracy. His aim, like P.T. Barnum before him, was pure entertainment. Yet fanciful as it was, "A Trip to the Moon" would serve as an introduction to the idea of spaceflight to hundreds of thousands of visitors.

No modest sideshow kiosk, "A Trip to the Moon" was housed in a magnificent 80-foot-tall railroad station-like structure covering over 40,000 square feet. At a time when the average single-family home sold for \$2,000, it cost \$84,000. The 50-cent admission made it the most expensive show on the midway, twice the cost of most of the other attractions, like the adjacent "Streets of Mexico," "Upside-Down House," and

EARTH'S DEFENSIVE SHIELD

Light from the sun makes all life on Earth possible, but only because the magnetosphere and atmosphere filter out the star's deadly emanations.



Generated by processes deep within Earth, the magnetosphere extends some 40,000 miles toward the sun, and considerably farther as it trails away in the other direction. The magnetosphere ends where the force exerted on charged particles by



Interplanetary space begins

Exosphere

Thermosphere
ends

Ionospheric
reflection

Aurora

Outer mantle

3,000 miles •

• 300 miles

Layers of Air

The exosphere (300–3,000 miles altitude) is the highest level of the atmosphere. At its outer limit the particle density is equal to that of interplanetary space.

The ionosphere is the region of the atmosphere where

...ners, who
...rned to
...ue the com-
...ss, have long
...en aware of
...ffects of
...th's magnetic
...but its origin is

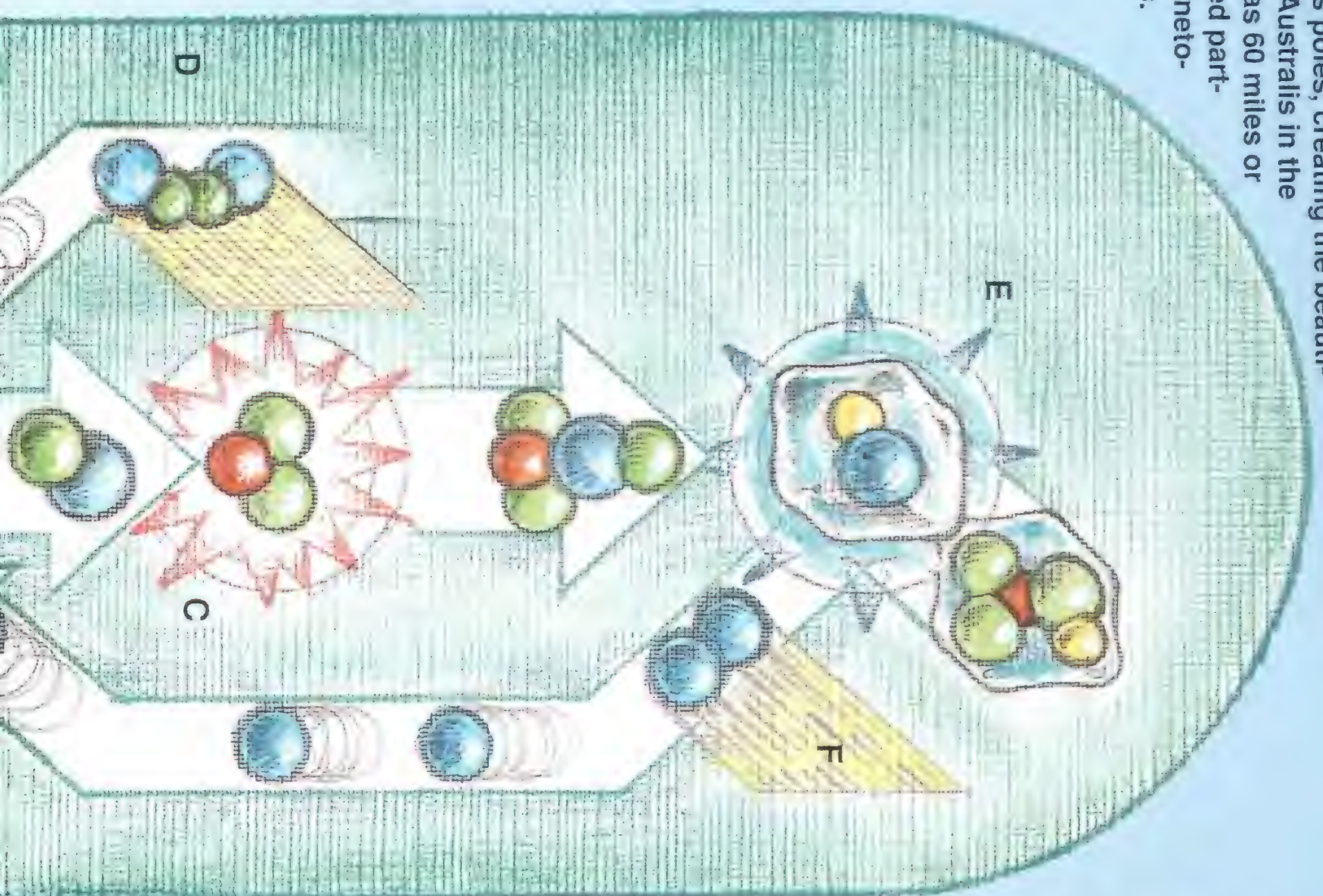
Earth's magnetic field is counterbalanced by the solar wind. The area of equilibrium is the magnetopause.

The magnetosphere prevents many of the solar wind's high-energy particles from reaching the planet, but some are accelerated and funneled toward Earth's poles, creating the beautiful auroras (Borealis in the north, Australis in the south). Auroras can occur as low as 60 miles or as high as 600 miles. Other charged particles are contained within the magnetosphere in Van Allen radiation belts.

The Antarctic Ozone Hole

In 1985 British scientists in Antarctica discovered a "hole" in the shield of ozone—the tri-atomic form of oxygen—that protects organisms from the sun's dangerous ultraviolet light. Research linked chlorofluorocarbons (CFCs), inert industrial chemicals used in spray cans and refrigerators and for other industrial purposes, to the destruction of the ozone (right).

- (A) CFCs are stable in the lower atmosphere. In the stratosphere, ultraviolet breaks them down, releasing highly reactive chlorine.
- (B) Chlorine reacts with ozone, releasing molecular oxygen and chlorine monoxide.
- (C) Chlorine monoxide can react with nitrogen dioxide to form an inactive "reservoir" molecule: chlorine nitrate.
- (D) OR: Two molecules of chlorine monoxide can combine; ultraviolet light releases the chlorine atoms, which rejoin the cycle.
- (E) Antarctic ice clouds provide a surface on which chlorine nitrate can combine with another reservoir molecule, hydrogen chloride, to form nitric acid and two bound chlorine atoms.
- (F) When spring returns to Antarctica, ultraviolet light splits the chlorine atoms, which return to the cycle and destroy more ozone.



debated.

Scientists do know that the planet's center is composed of a solid iron-nickel central core and a liquid outer core. As the Earth

rotates, the cores spinning with it, but at different rates. According to the most widely held theory, interactions between magnetically charged inner and outer cores create an electrical current in the outer core. This current induces an electrical current in the inner core. This current in the outer core



Inner core

Outer core

Inner mantle

• -3,960 miles

• -1,800 miles

-600 miles

Radio. Long wavelengths, penetrates atmosphere easily.

Infrared. Shorter; some wavelengths can reach the ground.

Visible. Some is absorbed or scattered, creating the blue sky.

Ultraviolet. Mostly absorbed by ozone in the upper atmosphere.

X-Ray. Extremely short wavelengths, does not penetrate atmosphere.

Gamma Ray. Shortest wavelengths, does not penetrate atmosphere.

energy from the sun ionizes atmospheric molecules, causing them to either gain or lose electrons and thus acquire a net electrical charge. Radio waves bounced off the ionosphere can travel great distances. Beginning near the stratopause at an altitude of 34 miles, the ionosphere extends to a point several Earth radii in space.

In the thermosphere (50–280 miles), temperature increases until the region ends. At about 60 miles above the surface, atomic oxygen becomes an important component. By the outer limit, the thermopause, the air is so thin that molecules rarely collide.

Temperatures in the mesosphere (30–50 miles) decrease with altitude, dipping as low as -170° when this region ends at the mesopause.

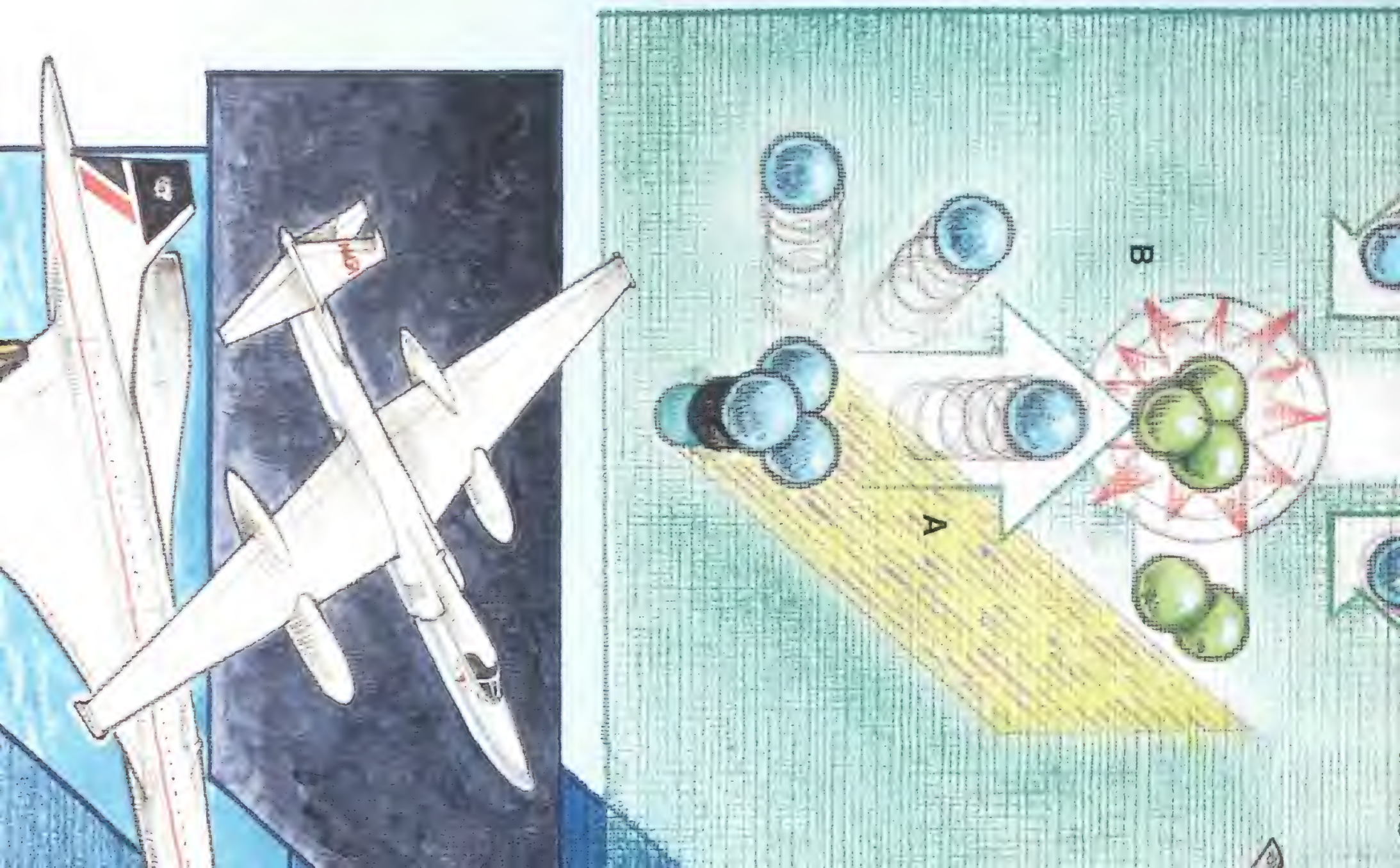
generates another, stronger magnetic field such as a magnetic field is generated by electricity passing through a wire coil. One mystery: geoelectric evidence indicates that the field's orientation sometimes reverses.

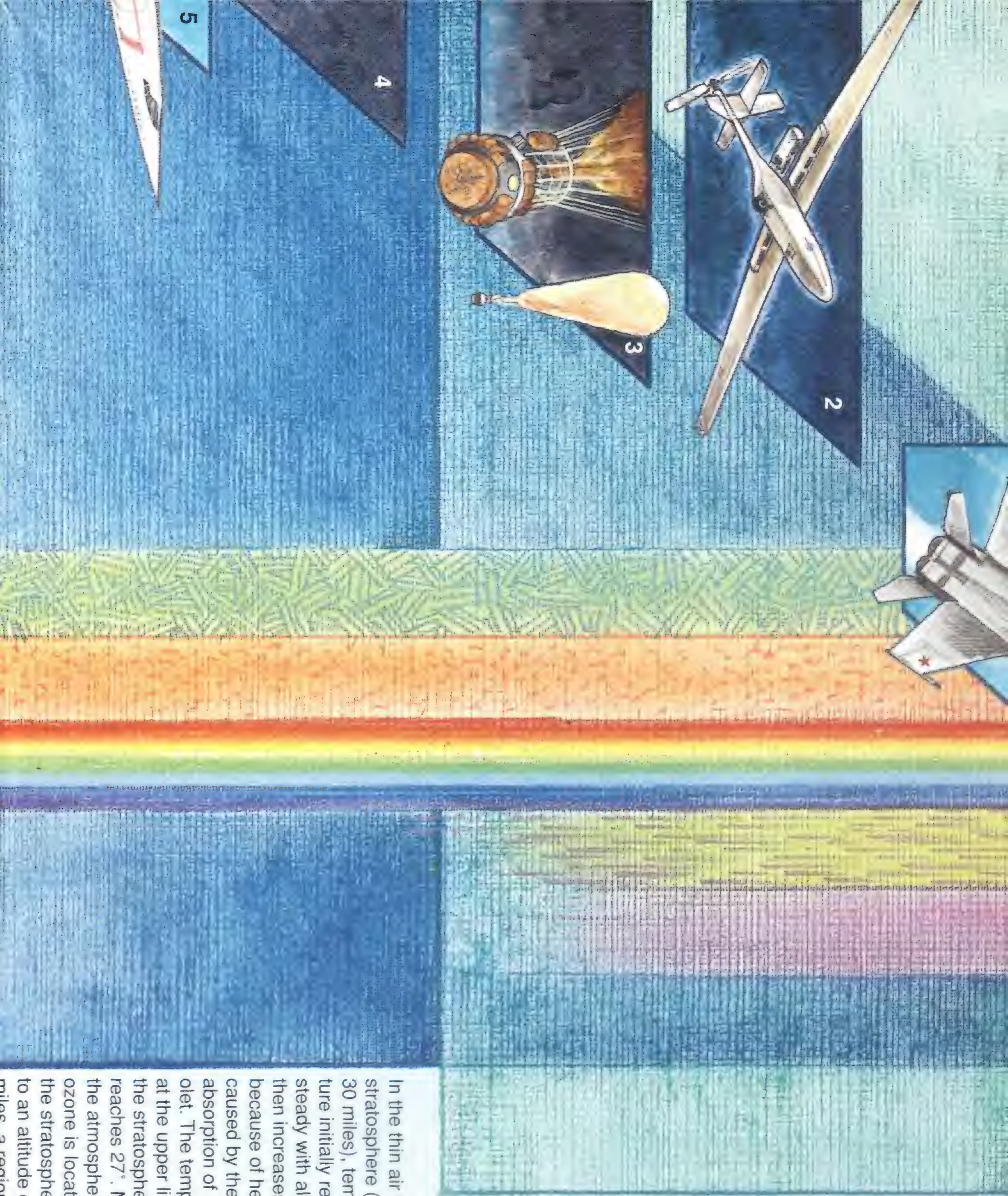


Into the Wild Blue Yonder

Initially inspired by the flight of birds, for centuries humans have longed to travel ever higher in the atmosphere. Since the first balloon flights, people have sought altitude for any number of reasons: to expand scientific knowledge, to bask in heroic achievement, or merely to travel with speed and comfort. As the atmosphere thins, aircraft and balloons reach their limits and the realm of spacecraft begins—NASA awards astronaut wings for flights above 50 miles.

- (1) The current altitude record for air-breathing craft is held by a Soviet E-266M, the prototype for the MiG-25, which reached 123,524 feet on August 31, 1977.
- (2) Perseus is a remotely piloted craft designed to study the atmosphere at altitudes of 85,000 feet with a mobility balloons lack.
- (3) Balloons—manned and unmanned—have been important for stratospheric research. In 1935 two men aboard Explorer II reached 72,395 feet.
- (4) NASA operates the ER-2 variant of the U-2 spyplane to conduct atmospheric research at altitudes of around 65,000 feet.
- (5) The supersonic Concorde carries its passengers across the Atlantic at 55,000 feet. In the 1970s an American SST project was canceled in part because of worries about the effect of these high-flying craft on stratospheric ozone.
- (6) The Boeing 777 flies in the relatively calm air up to 43,000 feet. At such altitudes, cabins must be pressurized to sustain life.
- (7) Wiley Post conducted pioneering studies of the jet stream in his Lockheed Vega *Winnie Mae*. On June 15, 1935, Post attempted a transcontinental flight by flying in the jet stream at 35,000 feet.
- (8) Birds ordinarily don't fly much above 8,000 feet or so, but scientists have tracked transoceanic migrations that have gone as high as 21,000 feet.
- (9) In 1804 Joseph Gay-Lussac and Jean



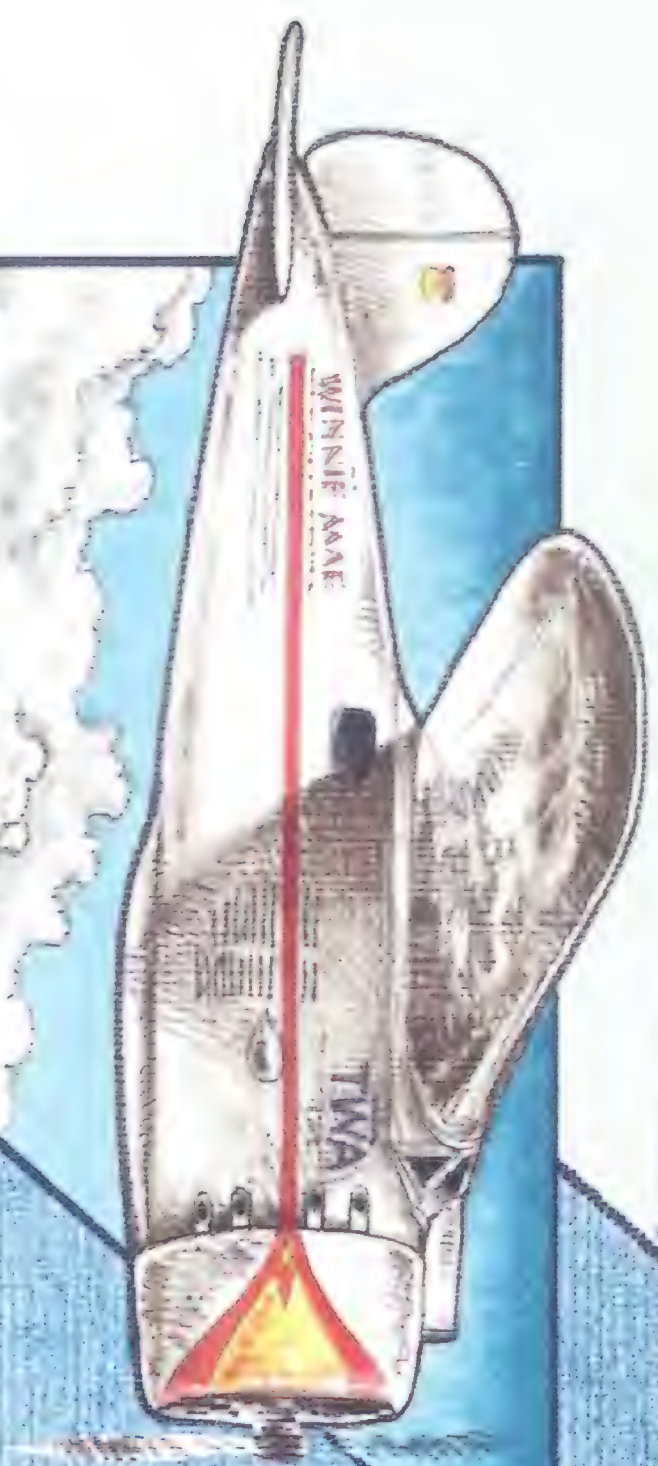


In the thin air of the stratosphere (up to 30 miles), temperature initially remains steady with altitude, then increases because of heating caused by the absorption of ultraviolet. The temperature at the upper limits of the stratosphere reaches 27°. Most of the atmosphere's ozone is located in the stratosphere up to an altitude of 25 miles, a region that

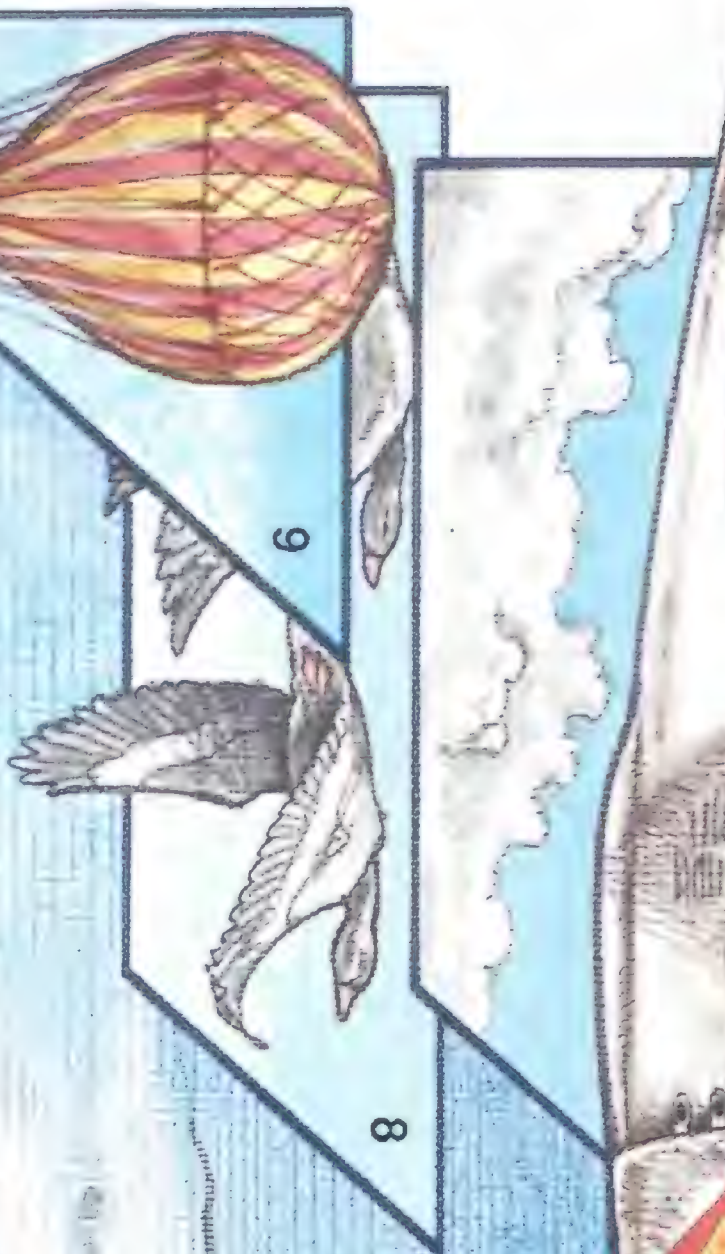
Baptiste Biot made the first scientific flight, taking a balloon to 19,000 feet to collect air samples. Gay-Lussac later ascended to 23,000 feet.



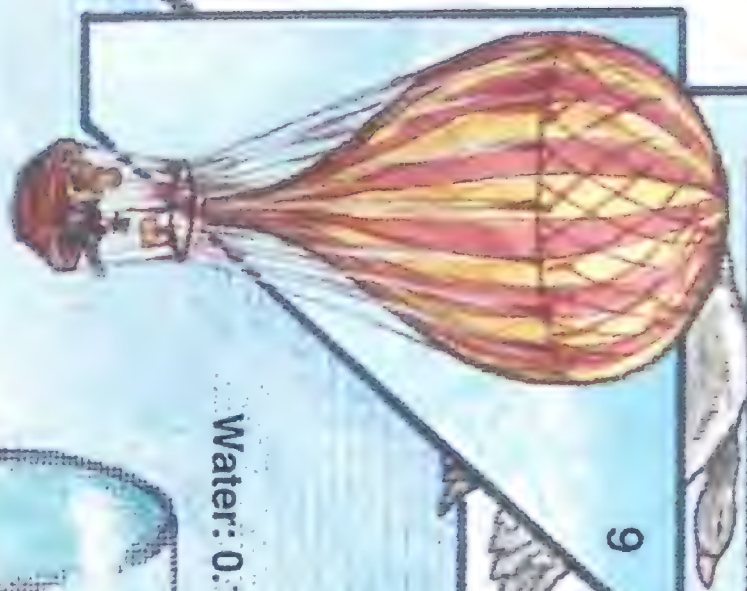
6



7



8



9

Mt. Elbrus (Georgia) 18,510 ft

Mt.

Vinson Massif (Antarctica) 16,864 ft

Mt. Kosciusko (Australia) 7,310 ft

Water: 0.1–4%

Nitrogen: 78%



has become known as the ozone layer. The stratosphere ends at the stratopause, or mesopause.

Depending on conditions, the troposphere can extend from Earth's surface as high as 11 miles over the equator or as low as 4 to 5 miles at the poles.

Normally, temperature decreases with altitude throughout this region. The tropopause marks the transition between the troposphere and the stratosphere.

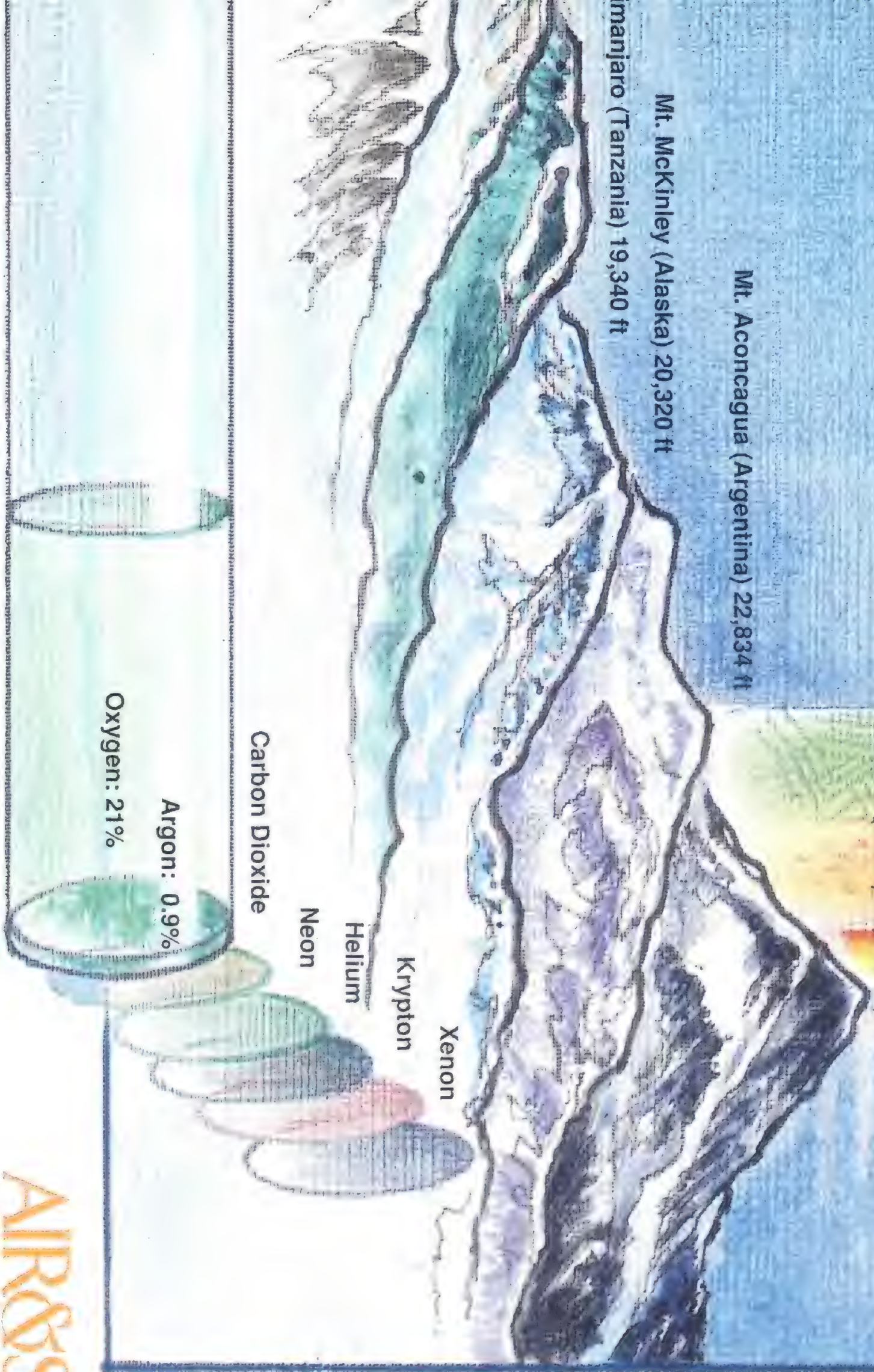
The air in the troposphere, stratosphere, and mesosphere contains the same basic proportions of gases (left). Together the three regions are known as the homosphere.

Mt. Everest (Tibet) 29,028 ft

Mt. Aconcagua (Argentina) 22,834 ft

Mt. McKinley (Alaska) 20,320 ft

Kilimanjaro (Tanzania) 19,340 ft



AIR & SPACE

Smithsonian














All Chrysler Corporation vehicles made
since January, 1994 have air conditioners
that use CFC-free refrigerants. Thanks to
safer substitutes and system redesigns, we are
years ahead of government guidelines. It's
just one small step to solving a problem
that's been hanging over all our heads.

C H R Y S L E R 
C O R P O R A T I O N

Chrysler • Plymouth • Dodge • Dodge Trucks • Jeep® • Eagle

THE OZONE LAYER
HAS PROTECTED US
FOR 1.5 BILLION YEARS.

IT'S TIME WE
RETURNED THE FAVOR.

TO THE MOON

Even before the first airplane flew, an imaginative showman was taking passengers into space.

by Frank H. Winter
and Randy Liebermann

"Filipino Village." Thompson's "Aerial Navigation Company" offered lunar trips every half-hour, with a seating capacity of 30.

An architect by training, Thompson designed both the building and the illusion. He got an entrée into the amusement business at the 1893 Columbian Exposition in Chicago, where, fascinated by the business, he had taken a janitor's job at a machinery exhibit but proved so valuable he was put in charge. He later built most of the midway shows for the 1898 Trans-Mississippi Exposition at Omaha, Nebraska.

In a variety of newspaper and magazine articles, Thompson wrote of how he dreamed up his trip to the moon. At the time, about 1900, he was already working on a show for the Pan-American Exposition called "Darkness and Dawn"—known to the less reverent as "Heaven and Hell." He had devised a macabre effect in which visitors would step into coffins, which hidden elevators would then lower into the "bowels of the earth." Thompson had planned various trips through Hell for his guests but was still deliberating over how they would cross the "chasm of fire."

"I had several ideas in my head," he wrote, "all of which were unsatisfactory until I hit upon an idea, an airship...it struck me that this was an idea for a show in itself...and I immediately thought, 'Where will I take the airship?' And then it occurred to me. 'To the moon.' I jumped up...and practically developed 'A Trip to the Moon' before I retired that night."

The notion of a lunar voyage was not original; Thompson may well have been inspired by the classic 1865 Jules Verne novel *A Voyage to the Moon*. But there were other possible sources for the con-

cept. The play "A Trip to the Moon," based upon Verne's masterpiece, was presented in New York's Booth's Theater in 1877 and perhaps elsewhere. Popular well into the 1890s were "dime novels" with such stirring titles as *Six Weeks in the Moon*, featuring an airship, and *The Rocket; or Adventures in the Air*, which appeared in 1899. In 1892, a well-publicized early form of the slide lecture called "A Trip to the Moon" was shown for several nights in New York's Music Hall, and in 1893 the Lilliputians—a company of midget actors—were a smash hit at that city's Niblo Theater with a music and dance production called "A Trip to Mars."

Thompson's originality lay in his creation of the first electrical and mechanical space extravaganza, the forerunner of all amusement park space rides. He created other firsts too. Thompson was so confident in his new undertaking that he eventually copyrighted the script for the live-action portion of the lunar journey and patented his lunar craft—U.S. Patent no. 725,509, granted on April 14, 1903. This may well have been the first spaceship ever patented.

The whole flavor of the craft was nautical. Its inventor termed it an "aerial ship" but told the public it went to the moon by "anti-gravity." It came with "decks," a "deck-house," a mast, ropes, and pulleys. The passengers sat on "steamer chairs" on the open deck.

Projecting from the ship's bows were a series of large, bird-like wings. Cables and rods linked to motors made the wings slowly flap, while

hidden fans produced the illusion of wind. Independently movable screens surrounding the vessel were painted to show different strata of clouds as the ship "ascended." Meanwhile, a series of skillfully arranged scenic drops provided the effect of sailing from Earth toward a twinkling sky. The screens also moved at different speeds to add the illusion of movement. At the same time, the ship's deck itself gently rocked. The simulated



The airship Luna sailed from Buffalo, over Niagara Falls, and to the moon only in her creator's imagination (opposite). But at the 1901 Pan-American Exposition, she simulated the experience for thousands of paying passengers—who emerged from their trip with the souvenirs to prove it.



Frederic Thompson, the architect and visionary behind "A Trip to the Moon," also had a passion for aviation, even starting his own short-lived airplane manufacturing company in 1910. His true genius lay in detailed flights of fancy, as this promotional leaflet shows.



"Trip to the Moon" was scheduled to debut the same day. The ship, dubbed *Luna*, apparently had already been christened with a bottle of champagne by one of the dancers. Yet *Luna* still could not "fly." Electricity had only relatively recently been harnessed, and the midway had been experiencing power failures lasting for days at a time. Thompson complained of five blackouts in one night.

On top of this, like modern spaceships, *Luna* herself was beset by last-minute technical glitches. Thompson, or his press agent, cleverly disguised the problems, at the same time heightening the publicity by spreading tongue-in-cheek stories to the press. The ship, reported the *Buffalo Express* of May 12, "suddenly broke away from her moorings and soared upward, taking part of the temporary roof of the Trip-to-the-Moon building with her. Mr. Thompson doesn't care much about the roof, but says he is a ruined man if he doesn't get the ship back." Three days later, the *Express* noted Thompson's "tearful" joy that the Lick Observatory in California had located the runaway ship and that it would surely be ready on Dedication Day. A bulletin was also posted in front of the "Trip" building saying that "Captain Dickson

telegraphs by the Marconi system that he and the airship are now 478 miles from Buffalo at an altitude of 68 miles" and that the weather had been bad and blown *Luna* off course, though "if everything goes well the ship will reach the Midway on May 18th, but it will be here without fail on the 20th...."

Of course, *Luna* had really never left her moorings, and in fact there had been at least two test runs, on the 18th and 22nd. Some newspaper accounts also disclosed some of the true technical difficulties. One paper mentioned the "non-arrival of certain delicate appliances which were vital to the successful production of the illusion," while another said, "Something went wrong with the electrical contrivances" and "Mr. Thompson had no recourse but to close his doors," though thousands had applied for admission.

Finally all the pieces came together, and at 7 p.m. on the 23rd, after much anticipation, *Luna* made her first public trip.

After the passengers entered a sumptuous lobby appointed with chandeliers, they found themselves on a platform, "like the waiting-room on a railway station," according to one account. In a moment *Luna* appeared, a brilliantly lit green-and-white cigar-shaped craft "the size of a small lake steamer, with a great cabin in the middle," her colossal red canvas wings stretching out like those of "some huge bird." The captain beckoned the passengers aboard and explained the various features.

At the sound of a gong, the ship started slowly rocking, gradually increasing its gentle motion. As clouds floated around the ship, the voyagers could see below them, through the railings, a miniature version of the city of Buffalo and the exposition, the buildings and towers glowing with "a thousand blinking lights." Niagara Falls appeared. Then the scene switched to one of Earth, its sphere diminishing in size until it

sounds of boat chains clanging, startlingly realistic thunder claps, lightning flashes, and other dramatic lighting effects added to the illusion.

Ground was broken for the "Trip" building in late July 1900. Construction also began on the "fine steel airship of the latest pattern," as one newspaper reported. Meanwhile, Thompson advertised both in the United States and abroad for performing midgets, giants, and dancers. He also engaged artists and, by February 1901, had 20 on the payroll. Eventually, his total cast numbered 200, including 60 midgets.

Plans had called for the Pan-Am Exposition to open on May 1, but a severe late-April snowstorm pushed back the inaugural ceremonies until May 20. "A

was a mere speck. En route to the moon, the travelers encountered a fierce electrical storm with thunder, lightning flashes, and "whistling wind." After the storm ceased, the ship passed through "an atmosphere of light blue hue when an awful screech of a strange monster flew through the air."

Now passengers spotted the moon: "...the face of the Man in the Moon is plainly visible. Rocks and lava pilings, stained red and yellow and green...are just ahead." *Luna* slowed up, veered to the right, then struck something solid.

The captain announced their destination had been reached.

Out stepped the travelers into a wondrous scene. Midget "Selenites" with spiked backs greeted them within the crater of an extinct volcano overflowing with fungi, stalactites, and "crystallized mineral wonders." The Selenites led the visitors down a long illuminated avenue lined with toadstools and fantastic trees to the City of the Moon, where weird bazaars and shops sold souvenirs and gave demonstrations of carving and weaving. Some Selenites offered the visitors samples of green cheese. The tourists were then taken to a broad moat and, beyond, to the castle of the Man in the Moon.

In the spacious throne room, adorned with glass columns and bronze griffins, the guests were offered seats. Here the king, on a mother-of-pearl throne flanked by giant bodyguards, treated the visitors to views of the "Geisler electric fountain," which displayed all the colors of the spectrum through its splashing waters. At the height of the display a dozen girls, the maids of the Man in the Moon, entered in a rhythmic, grace-

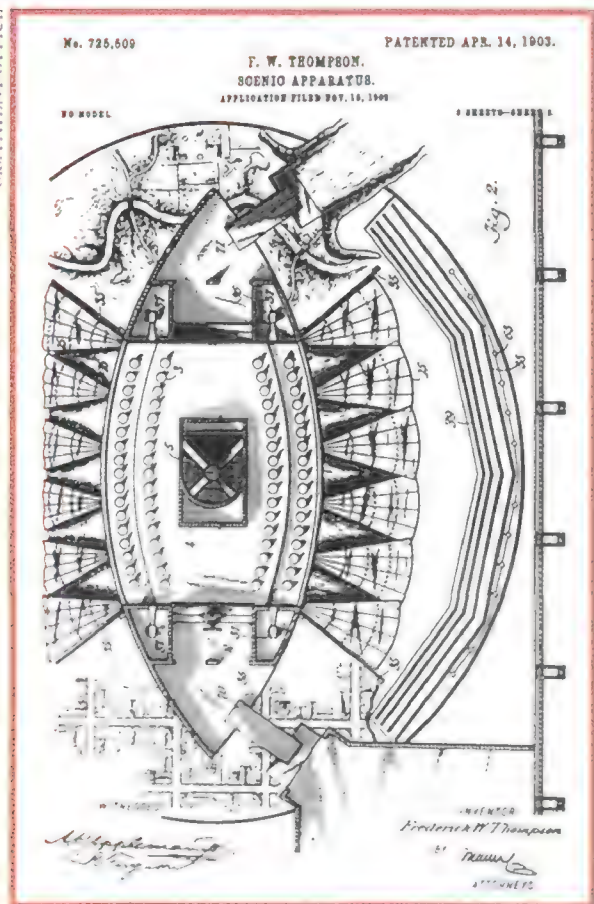
ful dance. Then they faded away, the curtain fell, and the show was over.

In that simpler, pre-radio and television age, when the public got its entertainment largely from vaudeville and the embryonic motion picture industry, Thompson's production was an amazing technical and artistic achievement that delighted all. Indeed, there were many notables who raved about the 20-minute show.

One of the first was Chauncey M. Depew, railroad magnate and U.S. senator from New York. After the performance, Depew, who had befriended every president since Lincoln, remarked, "In all my travels I have never seen anything so marvelous." After landing on Earth, Secretary of War Elihu Root was asked if he thought airships could be used for warfare. "If they are all as successful as this one," he replied, "they would work very well." The secretary also described the ride as "elevating," a term Thompson quickly adopted in his advertising. Secretary of State John Hay was so enthralled that when in the throne room of the Man in the Moon, he sent for Thompson and gave him a \$20 bill "for distribution among the inhabitants of the Moon" as a token of his appreciation. Senator Thomas C. Platt from New York called the show's creator a "genius," while General Nelson A. Miles, the commander of the U.S. Army and the man who captured Geronimo in 1886, asked questions throughout and deemed the show "a wonderful idea cleverly worked out." Ambassador Wu Ting from China was especially intrigued by the midgets and wondered "where they came from, how they enjoy life, and how long they live."

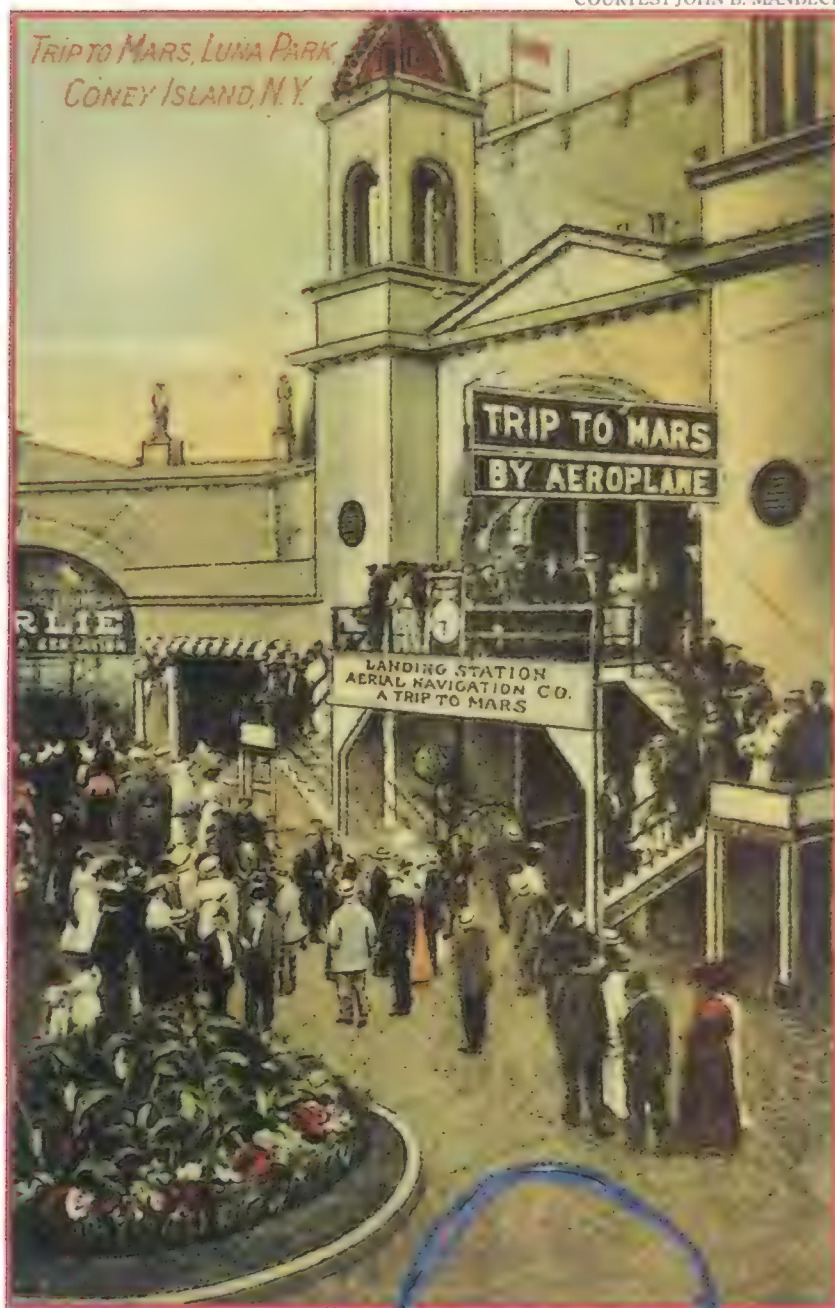
It is not known if Nikola Tesla, the great, eccentric electrical inventor, took Thompson's ride, but he was certainly aware of it and offered some observations. He had visited the exposition in late March before its opening, and in July he wrote to Thompson, probably in self-mocking reference to his own experiments with radio, that he had "received a communication from Mars." The Martians had seen the preparation of one of *Luna*'s voyages, he informed Thompson, and from a balloon had "waved their pocket handkerchiefs at the Moonshiners."

No less than Thomas Edison himself



In 1903 Luna became probably the first spacecraft ever patented (left). That same year, the ride became part of a bigger Thompson attraction, Luna Park, in New York's Coney Island. A postcard captures some of the ride's whimsy (below).





A view of the Pan-American Exposition shows Luna atop the original "Trip" building, though she actually appeared inside (right). But by the end of the decade, Thompson's fancy, along with the world's, changed from imaginary spaceships to airplanes. By 1910 the ride at Luna Park had become a "Trip to Mars by Aeroplane" featuring a simulated airplane race to the Red Planet.

saw the show, on July 31, and expressed his "wonder and delight" over its "electrical miracles." He personally congratulated Thompson's electricians. The Edison Company later made a film of the ride and other midway attractions, using their latest "projecting kinoscope."

It is uncertain whether Edison's "Trip to the Moon" of 1901 was the first film ever made of spaceflight, but it does appear that William McKinley became the first—and only—U.S. president to visit the moon, via *Luna*.

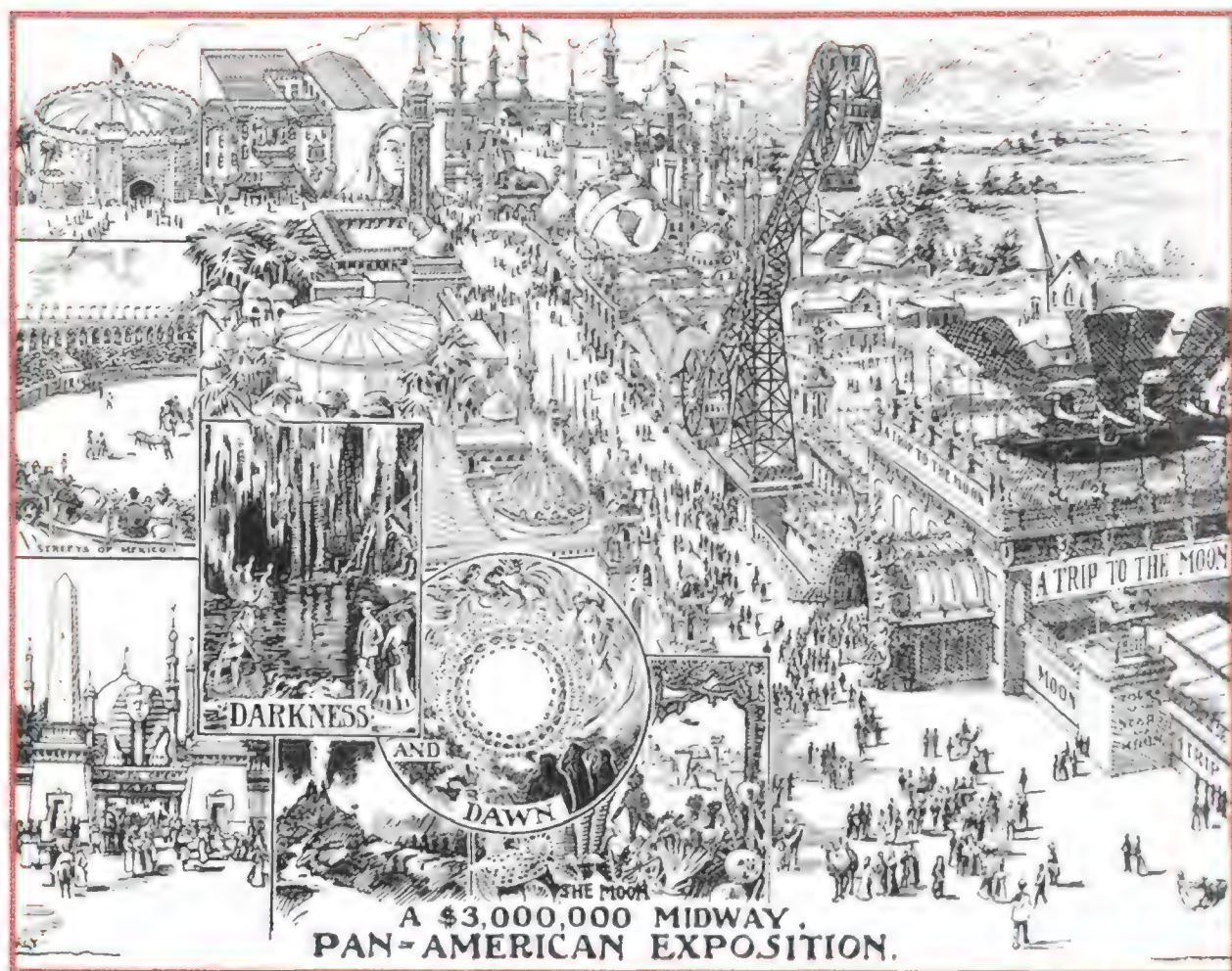
It is not known exactly when McKinley paid the visit. Most likely it was on the evening of his first day at the Pan-American Exposition, September 5. Following a packed day of attending receptions and delivering an address, the president and Mrs. McKinley were escorted to the exposi-

tion grounds. One of Thompson's publicity brochures, published two years after the event, quotes McKinley as saying: "A Trip to the Moon is ideal. It was the most marvelous experience of my life." On the following day, September 6, the president had completed another address, at the exposition's Temple of Music, and was shaking hands when a crazed anarchist, Leon Czolgosz, shot him. McKinley died eight days later.

Despite the tragedy, "A Trip to the Moon" had been a tremendous success, and by October its seating capacity was doubled. Overall, some 400,000 people visited it, including some enthusiastic repeat customers. It was claimed that every member of the U.S. cabinet had gone, as well as several governors and most justices of the Supreme Court.

Following the exposition, the "Trip" found its way to Coney Island, where for the 1902 season it joined George C. Tilyou's Steeplechase Park. Here too it was a smash. Then Thompson created "Luna Park" at Coney Island, and a place once known for its bawdy gambling and saloon-ridden beach resorts became a family amusement attraction. "A Trip to the Moon" was again a stellar draw when the park opened in the summer of 1903.

Marvelous Luna Park, with its minarets,





myriad rides, quarter-million lights, and respectability, made Thompson a millionaire. The idea caught on, and Luna Parks sprouted in nearly a score of cities, some overseas. Ironically, none seem to have adopted “A Trip to the Moon”—probably because it was so costly and required the showmanship genius that Thompson epitomized.

Thompson undoubtedly owed some of his success to one other man: Elmer “Skip” Dundy, a financial genius. Thompson first met the stuttering, astute Dundy as a fellow competitor at the Omaha exposition, then again at Buffalo, where Thompson persuaded Dundy to join him. Dundy thus became the principal backer for Thompson’s lunar extravaganza and its business co-manager.

The two made an unbeatable pair, but Dundy died in 1907, leaving Thompson without anyone to control his soaring debts and spendthrift habits—like paying and tipping for drinks with ten-dollar gold coins. He started drinking

heavily. Extremely close to his mother, he had not married until his mid-30s, and the marriage quickly ran aground. He divorced in 1912 and then remarried. But his alcoholism and feverish work pace led to a succession of illnesses and operations, the last of which, in June 1919, he did not survive.

“A Trip to the Moon” had meanwhile begun losing its novelty and closed around the time of Dundy’s death. In 1910 it saw a revival at Luna Park as “A Trip to Mars by Aeroplane,” but closed two years later. In 1913 a New York paper reported that the “Trip” would be included in the Panama-Pacific Exposition in San Francisco for 1915, but there is no evidence it actually was.

Luna Park too went into decline. The park’s later managers were more business entrepreneurs than artistic showmen. They did not go in for lavish productions, which in any case went out when movies supplanted vaudeville. A succession of fires and hard economic

Beautiful Luna Park, shown in a circa-1905 postcard, continued to change with the times; it’s now the site of the Luna Housing Project.

times also took their toll, culminating in August 1944, when a fire destroyed Luna Park’s remaining buildings, including the one that once housed “A Trip to the Moon.” A few years later, Fred C. Trump, Donald Trump’s father, bought the property and converted it into the Luna Housing Project.

But the simulated-spaceflight amusement ride saw a virtual renaissance in 1955 when the newly opened Disneyland featured “Rocket to the Moon.” Though the ride was more modest than Thompson’s creation half a century before, the Space Age was by this time just around the corner. With it would come technologically fantastic journeys Frederic Thompson himself could scarcely have imagined. ➤

LIFE IN THE EGG

Sixty feet beneath a bleak Midwestern outpost, a handful of men stood ready to annihilate the Soviets.

by Michael R. Boldrick

Illustrations by Paul DiMare

Kathleen's call came at 7 a.m. On her way to the hospital she would drop two-year-old Peggy at a friend's house. The Pontiac would be parked near the emergency room entrance.

I wished her well and hung up. Once again, I'd be late for an important event in our young marriage—this time the birth of our second child. At the moment I was babysitting 10 nuclear missiles.

Katherine Rose Boldrick entered the world on October 8, 1968. It was the heyday of Mutual Assured Destruction, the era when the United States and the Soviet Union watched each other through crosshairs. A handful of Strategic Air Command (SAC) officers kept the hammers cocked on a thousand long-range missiles. Duty came first. Pregnant wives were expected to drive themselves to the hospital.

Occasionally I am asked why I did it—why I agreed to spend four years working deep beneath the Midwestern prairie, missing holidays, birthdays, and other precious time with my family. To start with, I had decided to make the Air Force a career, and missile duty promised more challenge than pumping out press releases as a public affairs officer. Besides, officers operating aircraft and missiles get promoted faster than their peers serving in support capacities. I also had a great curiosity to learn under what circumstances, and how, our nation would commit its nuclear forces. And the Air Force offered a special enticement: missile launch officers could earn a master's degree during their four-year duty tour. I got mine in economics.

What was the job like? Two short

sentences sum up the experience: "To err is human, to forgive divine. Neither is SAC policy." Since we were the final link between the president and the angry firing of rockets armed with nuclear warheads, our lives were as tightly controlled as the awesome weapons we operated.

Every new crew member was quickly "SACumcized," taught that there is a right way, a wrong way, and the SAC way. The latter is enforced by no-notice visits from the inspector general. The elite IG team, brainchild of legendary tough guy and SAC head General Curtis E. LeMay, operated strictly by the book. Because SAC was part of the Air Force, SAC units got every service-wide directive that other Air Force personnel got, but virtually every one came with blue-paper supplements detailing SAC's special interpretations, amendments, and additions. We'd say to newcomers: "Did you hear the chaplain failed the inspection?" and when they asked why, we'd spring the punch line: "He hadn't posted the SAC supplement to his Bible."

I was on duty in an underground missile launch control center during my first IG inspection. When the team left, I called upstairs and asked how our site had done.

Not bad, according to the sergeant. Only one black mark. Dutifully, the IG had followed a checklist requiring a test of each light fixture to verify that sufficient illumination was available for night operations. Burned-out bulbs were a sign of poor discipline. Inside a garage housing snow removal equipment, the IG flipped the light switch. The bulb flashed brightly, then went out. The sergeant was written up for "burned-out light bulb."

The wee hours provided some relief from the unceasing demand for perfection. The five launch control centers in each 50-missile squadron were connected by a party line called the Hardened Voice Channel, or HVC. Like the control centers, the HVC was underground, making it somewhat survivable during an attack. The HVC was completely private, so we could talk freely. One night, a colleague put things into perspective as the other four centers listened. "Hey, guys," he said, "I've got it figured out. On our way to South Dakota each of us was killed in a terrible auto accident so sudden we don't remember it. Then the Big IG in the sky put it to us: 'Welcome to Hell. You're going to slog through the snow pulling eight alerts a month for all eternity. Those orders to Hawaii? They're never going to come.'"

Ipulled most of my tours watching over Minuteman I missiles at Juliet, South Dakota, the 44th Strategic Missile Wing's most remote site. Instructions for reaching "Julie" were simple: Drive to the edge of the world and hang a right. Julie was also one of our deepest sites. To reach our work quarters, each two-man crew descended about 60 feet on an elevator, or by ladder when one of the region's frequent thunderstorms knocked out Dakota Power and Light. At the bottom of the elevator shaft we waited for the duty crew to open a blast door heavy enough to guard a bank vault. Then we entered a low concrete tunnel, hunched over like apes. Four paces later we arrived at a 30-foot-long egg-shaped cavern. Its dimly lit shell was made of steel plates painted rust-resistant boxcar red. Hanging from the egg's ceiling

by four thick cables was the launch control center, essentially a room-size box. You got to it by way of a steel gangplank.

The control center was crammed with pale green racks of electronic equipment. A cot was tucked between a rack filled with radio gear and a combination stove-refrigerator. One crew member could sleep, but we never rested well because the lights

always shone, the electric generator hummed incessantly, and the radios crackled all night. A not-very-private privy occupied a corner near the entrance.

A commander's console dominated the back wall. About ten feet away, along the center's right side, a smaller console served as the deputy's duty station. Both the commander's chair and the deputy's





were mounted on tracks, which kept the chairs from being tipped over and allowed the crew to quickly slide down the rails to reach the racks of electronic equipment. During wartime, crew members would be able to fasten safety belts and lock

the chairs in a rigid position.

The commander's console had 100 status lights, 10 for each missile (Juliet 2 through 11). When all was well, the missile status indicator panel was dark except for a row of ten green lights lettered "strategic alert."

Other bulbs, mostly red, would light up, accompanied by a harsh-sounding alarm, whenever something (usually a jackrabbit) got too close to a missile silo or a piece of support equipment malfunctioned. Status lights were tested daily for



those career-threatening burned-out bulbs.

Special coded panels, notable because each contained a keyhole, were at the commander's right and the deputy's left. A small double-locked red box, anchored to the floor

different delay times built into them; after the keys were turned, you might see one or two missiles take off right away, with others lifting off at various times over the next hour or so. Once on their way, the missiles would reach their targets, 4,000 to

next to the cot, held the launch keys and a portion of something called the Go Code. Like the map in Robert Louis Stevenson's *Treasure Island*, the Go Code's pieces were useless by themselves. If a launch message was transmitted, the crew would open the combination locks on the red box and, conferencing with other crews over the HVC, collectively assemble the entire code. If it matched the one transmitted in the execution message, we would know that the order had come from the president and thus gave us authority to launch.

Launching the missiles was as simple as starting the family car: insert key, turn right. The trick was, one crew could not launch its 10 missiles without the cooperation of another crew in the same squadron. Each crew would "arm" its own 10 missiles—prepare them to accept a launch command—and then all crews would turn their keys in unison. Once a missile received two launch commands from two different capsules, it was ready to go.

The missiles could lift off as soon as 43 seconds later, but various war plans had

6,000 miles away, in about 30 minutes. Though the Pentagon has never disclosed the Minuteman I's power, *Jane's Weapon Systems* has reported that each missile's single warhead may have had a yield of one megaton—66 times the power of the bomb dropped on Hiroshima.

After a war had been declared, the deputy would raise the control center's gangplank. At that point, the center would be attached to the capsule solely by the cables that suspended it from the ceiling. The idea was that an enemy attack would only cause the center to swing gently, rather than crash to the capsule's bottom.

No doubt nuclear blasts would collapse the elevator shaft, so the capsule designers had provided us with an escape route. When the attack was over, we would lower the gangplank back in place, leave the control center, and climb on top of it. Then, using a five-foot wrench, we would open a 544-pound round red door that was set in the forward curve of the egg. Behind the door, according to a drawing in the operator's manual, a three-foot-diameter metal tube, filled with sand so it could flex without breaking during an attack, shot toward the surface at an angle. It stopped five feet short of daylight, preserving the capsule's relative invulnerability, or "hardness." A shovel for digging the last few feet to freedom was stored with other emergency equipment.

The escape hatch was the source of endless discussion on the HVC. There were four theories. One: In the course of being dislodged from the ceiling, the 544-pound door would crush the crew. Two: If not, the sand draining from the tube would bury us alive. Three: The escape tube came to an end under the parking lot or the site's sewage lagoon. Four: There was nothing behind the hatch. It was a SAC placebo to make us believe there was an escape route.

Before each 24-hour tour of duty, or "alert," as we called them, we reported for a pre-departure briefing at wing headquarters. These briefings were always held at "oh dark thirty"—before sun-up. SAC never did

anything at 9 a.m. There was the usual harangue of thou-shalt-nots, followed by a 10-question Emergency War Order test, for which the minimum passing grade was 100 percent. Occasionally, a special intelligence briefing was held. The subject never changed: The Russians are coming.

One colonel, a visitor from SAC headquarters in Omaha with pilot's wings on his chest, took great delight in describing the latest from the Red Menace. The Russians were then deploying the giant SS-9 ICBMs, carrying multi-megaton warheads designed to crush our underground missile fortresses.

The colonel flashed a slide on the briefing room screen. It was a simple cross-section of a Minuteman site. The thin elevator shaft dropped below the bunkhouse into the earth, finally leading to the entrance of the egg-shaped capsule. The colonel then added an overlay depicting the quarter-mile-wide, 600-foot-deep crater that an SS-9 would create. Superimposing the overlay on the original slide gave the ludicrous impression that the little capsule was now suspended 500-odd feet above the crater's bottom.

"The blast doesn't hurt a bit," one crew member observed. "It's the fall to the bottom of the crater that gets you. Right sir?"

It was a long time before the next intelligence update.

Other visitors brought happier tidings. During my first year at Julie I drew Christmas Eve duty. The HVC was silent. Nobody wanted to talk. I began to feel sorry for myself. For the first time in our marriage, my wife and I would not attend Christmas Eve mass together. Peggy, three weeks shy of her second birthday, would have to wait until midday to open those enticing presents under the tree. Kathleen was having trouble assembling the dollhouse Santa Claus would deliver early the next morning. Reports topside said a light snow was falling. For those of us 60 feet under, a white Christmas was bad news—it could delay the helicopters that were to bring in relief crews.

About 10 p.m. the direct line from

topside rang. The site manager was putting some packages on the elevator for the crew.

We opened the blast door and retrieved two boxes wrapped in Christmas paper. I called upstairs and asked who had brought them. The manager told us that someone had phoned earlier to ask how many were on site. The sergeant had hesitated. Could it be one of those no-notice security exercises? Was it a trap to trick the sergeant into divulging information useful to a saboteur planning an attack? Finally, reasoning that even the IG doesn't work on Christmas, the sergeant disclosed the number.

An hour later, a car pulled up at the site gate and honked. One of the security guards responded. The driver was dressed in dungarees and a cowboy hat. He handed the cop a brown paper bag filled with small boxes, then drove off. Later, we figured he probably came from one of the local ranches, even though the nearest was several miles away.

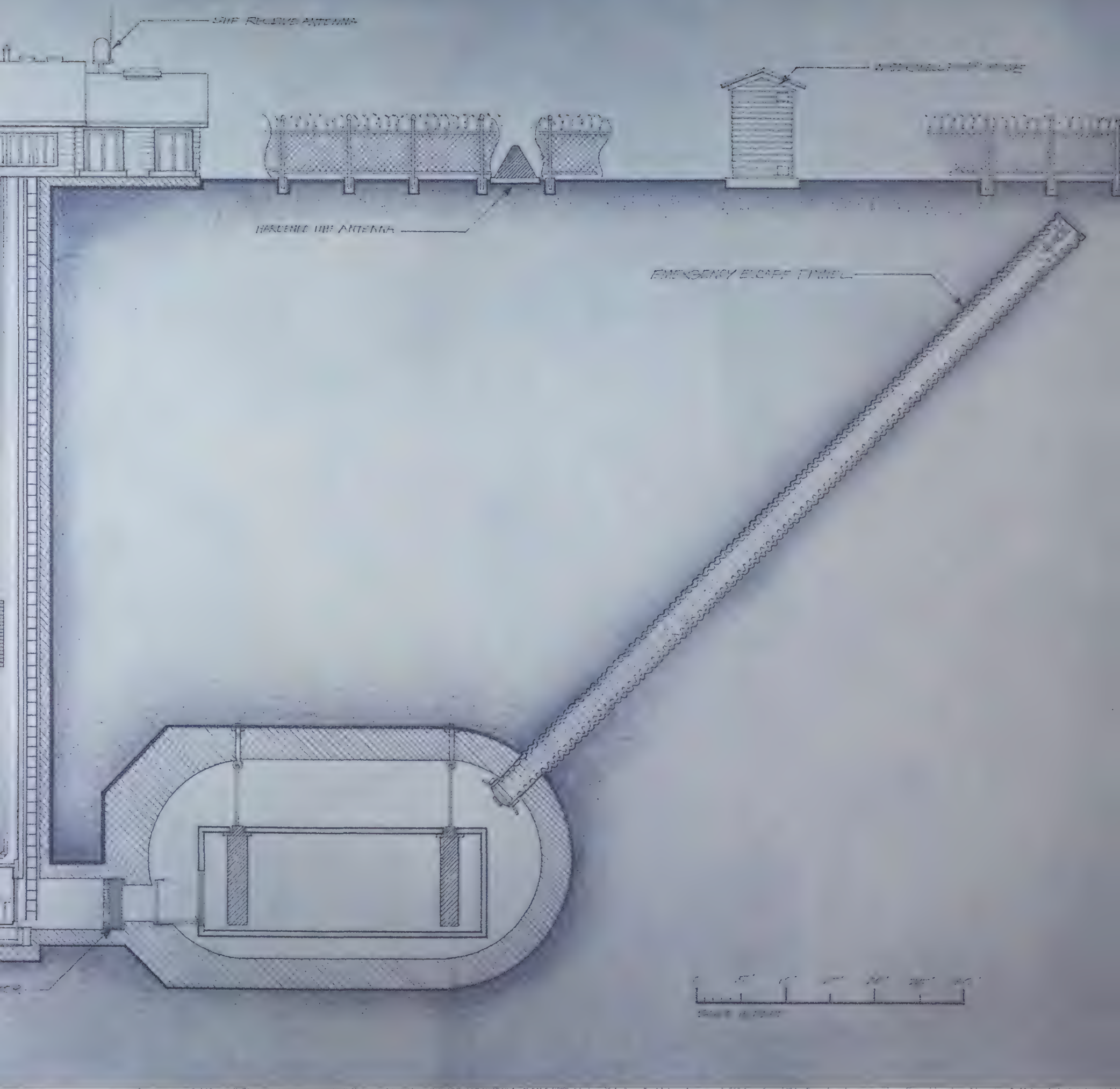
Inside the capsule we opened our boxes. They contained homemade candy and cookies and a handwritten note: "Thank you for watching over us this night."

Many times during each alert a *deedle deedle deedle* warbled from a speaker above the commander's console. It signalled that a Fast Reaction Message was about to be transmitted. When it sounded, we immediately opened a red Emergency War Order notebook and grabbed a black grease pencil so we could write down the message as it came over the speaker. Always it was an exercise. But each time it could have been a war order, sending us to the little red safe containing the Go Code and the launch keys.

Had that been the case, the stress level would have shot beyond the upper range of human tolerance. As we dialed the combinations to open the red safe, we would have been fully aware that an SS-9 with our name on it was at that moment arcing over the North Pole. Could we have completed our actions in time to launch the counterpunch? Or would a nuclear-

driven earthquake first crack the steel eggshell?

In the early-morning hours when I sat quietly among the humming green racks of electronic wizardry, I pondered nuclear war's aftermath. I imagined dropping the 544-pound escape hatch, dodging the falling sand, and wiggling my way up the escape tube. My shovel soon hit the roots of prairie grass. A few minutes later I crawled out of the earth.



Everything I loved was gone. My wife and baby girls had perished moments after the first *deedle*.

I got angry when I thought of all this. Yes, if attacked I would drop the hammer on 50 nuclear-tipped missiles. If a power was evil enough to destroy my family this way, I could not let it survive long enough to wreck another nation. I would have done the unthinkable.

Fortunately, that era is passing. On

September 27, 1991, President George Bush, in an initiative designed to ease tensions between the superpowers, reduced America's nuclear arsenal. About 40 heavy bombers and 450 Minuteman II missiles in Missouri, Montana, and South Dakota were removed from hair-trigger alert.

When SAC began carrying out the order, I watched a televised report from an alert shack at March Air

Force Base in California. Clad in flightsuits, the crews downed champagne with the gusto of Super Bowl champions. Many viewers probably thought the crews were celebrating the end of those seemingly endless seven-day alerts that fliers must endure. But I think not. That night they would no longer have to think about doing the unthinkable. That's worth a pretty tall drink. —



PETERS

by Tony Reichhardt

Illustrations by David Peters



*When the moon shines
in its exceeding beauty,
who would care to look at
a painted moon?*

*—Shankara, 8th century
Indian philosopher*

Mike McGreevy still has his copy of the July 1, 1966 issue of *Life* magazine, the one that first turned him on to the possibilities of virtual reality, although nobody back then would have called it that.

Inside was a panoramic photograph of the lunar surface, taken from one of the Surveyor robot landers. The image was actually a composite of more than 1,000 frames, fit together in a mosaic. That wasn't the real magic though. The article explained how scientists had taken the mosaic image and pasted it on the inside of a three-foot-diameter sphere. When they stuck their heads inside the globe through a hole in the bottom, it gave them a startlingly real impression of standing on the moon.

McGreevy was entranced. He started making his own photo-mosaics—of his parents' California ranch house, of everything in sight. On a trip to Paris he took pictures looking up from the base of the Eiffel Tower, pasted the images on the inside of a sphere, and achieved, he recalls, a "vivid sense of presence."

This fascination with illusion and reality eventually led McGreevy to NASA's Ames Research Center outside San Francisco, where in 1984 he and a colleague created a virtual reality headset out of a motorcycle helmet and TV components bought from a nearby Radio Shack. It wasn't the first head-mounted display of a computer-generated, three-dimensional scene. (That was the invention of Ivan Sutherland, who suspended a weighty metal headpiece on a tangle of electrical wires from the ceiling of an MIT laboratory in 1966.) But it helped move VR out of the realm of high-cost flight simulators and into the mainstream of modern culture. And it led to the first combination of the infant technologies of virtual reality with a natural companion—and McGreevy's other fascination—space travel.

THE CYBERSPACE PROGRAM

The Virtual Personal Trainer

The way Bowen Loftin sees it, shuttle astronaut Pierre Thuot might not have had such a problem rescuing the stranded Intelsat 6 satellite back in May 1992 if he'd had a little VR training beforehand. Despite months of rehearsal in NASA's underwater training tank, Thuot was caught off guard when the real satellite rebounded away as soon as he touched it. It took three tries and a risky, improvised spacewalk before the crew finally hauled in the spacecraft. The problem had been that there was no way to accurately simulate on the ground the physics of a satellite in a vacuum.

Unless, of course, they could have done it in virtual reality.

Loftin, who is developing VR systems at NASA's Johnson Space Center, got his first chance to apply VR training with the Hubble Space Telescope repair. For that mission, the astronauts used VR only to refine the sequence of movements they practiced in detail underwater. But the crew for this fall's STS-64 mission used a faster, higher-resolution VR system as its primary tool in training to fly a new mini-jetpack for

maneuvering outside the shuttle.

Jeff Hoffman, one of the space walkers on the Hubble repair mission, believes—as most astronauts do—that VR can never fully replace underwater training. But it offers some things the water tank can't, he says, like the sensation of working upside down, with your visual sense dominating your sense of gravity as it does in space. Hoffman thinks future VR systems will be used in combination with underwater training. "You'll work in a tank, seeing a huge space station out in front of you in virtual reality," he predicts.

VR's biggest drawback for astronaut training is its inability to accurately simulate the sense of touch and "force feedback." Nevertheless, Hoffman regards it as an ideal training device for EVA "because you've already got gloves and a helmet on," he says.

There have even been times during training, says the veteran space walker, when he's come close to being fooled. "I could almost get a suspension of disbelief, to the point where, when I'd take the helmet off after a session, I'd have to sort of shake my head a few times to get back to the real world."

Wearing a helmet, glove, and body suit in McGreevy's lab at Ames, you can reach down to the floor in front of you (except that inside your wraparound goggles it looks like the surface of Mars), "pick up" a virtual rock, throw it to somewhere else in the simulated scene, walk over, pick it up, and throw it again. It seems real, in an odd way. But all the action takes place inside the computer.

McGreevy produces the illusion, as do all creators of virtual worlds, by getting several technologies to work in concert. He starts with a computer powerful enough to assemble the millions of points that create a three-dimensional graphic display and to change them all every 1/30 of a second. McGreevy uses a 140-MIP (million instructions per second) multi-stream processor to create the scene from raw material—in this case, a laser scan of a place called Mars Hill in Death Valley, California. The Mars Hill data is the kind of imagery that McGreevy expects future planetary rovers to return.

The computer output shows up on a helmet-mounted display, the most common VR viewing system, which consists of two small liquid-crystal display screens, one in front of each eye. The screens display slightly offset views of the same scene to create the perception of three dimensions in the same way a Vu-Master does. They also have a wide field of view, so the wearer feels immersed in the virtual scene.

The helmet carries electronic sensors that communicate with transmitters in the room to track head position. The helmet's wearer can turn completely around and the scene displayed in the helmet will shift accordingly. The system could use digital images from planetary probes, but the Mars Hill data, unlike existing planetary data, offers a resolution of 10 centimeters (about four inches)—a human-scale environment. But a *realistic* environment?

Some researchers have gotten away from using the term "virtual reality," partly because it's become imprecise

and partly because it promises too much. If you believe what you see on TV and in the movies, soon we'll all be wearing goggles and gloves for everything from business meetings to sex.

Well, maybe someday. But not now. Forget the magazine pictures showing what a virtual world looks like from inside a helmet-mounted display. Those pictures show what other people in the lab would see if they were watching the same computer-generated scene on a high-resolution computer monitor. The picture *inside* your helmet, even one costing thousands of dollars, is more



likely to be a dim, grainy cartoon, nothing you'd ever confuse with reality. Most helmets are clumsy and ill-fitting, the resolution is poor, and the picture skips every time the computer updates the scene as you turn your head. *Star Trek's* Holodeck it ain't.

Helmet-mounted displays in military flight simulators can beat most of these problems, but only at tremendous cost and with a roomful of machinery to support them. Periscope-style VR displays mounted on movable booms offer an alternative to helmets, but these have limitations too. And VR simulation of touch is even more primitive. The truth is that good, low-cost VR simply isn't available yet.

Myron Krueger of Artificial Reality Corporation, one of the pioneers in the field, agrees that what you see through most helmets today is "pitiful." And he worries that because VR has had "the benefit of completely uncritical press," the public could turn on it before it really takes off. "Virtual reality would have

been a lot better off if it had not gone to sleep for 20 years," Krueger says, pointing out that most of the key technologies—helmet-mounted displays, head trackers, data gloves, and the algorithms to exploit them—had all been invented by the 1970s. For all the talk, not much real development work has been done since.

But that is certainly changing. Computer graphics alone have improved exponentially in the last few years, with rendering programs that can achieve ever more realistic animations at ever higher update speeds. Sega and Nintendo have been expected to jump into the virtual game market, and everyone in the VR world anticipates that toy R&D will drive the industry into a higher gear (see "You'll Love L.A.," right). And there's always the possibility of a genuine breakthrough. Take, for example, the Virtual Retinal Display now under development at the Washington Technology Center in Seattle. It would bypass helmet-mounted display screens altogether to scan stereoscopic images with life-like resolution directly onto the retina, using wireless hardware mounted on conventional eyeglasses, all for a few hundred dollars.

The Washington inventors aren't there yet, but they're working on it. In the meantime, NASA is making various uses of today's VR technology, such as it is (see "The Virtual Personal Trainer," opposite). And researchers at Ames are developing other tools that expand possibilities for virtual space exploration.

Dale Andersen is probably as close as anyone comes today to being a Mars explorer. An exobiologist at the Ames Research Center, he travels nearly every year to Antarctica, where he studies the primitive life that exists in dry valleys and ice-capped lakes in this most Mars-like of places.

As a field scientist, Andersen would always prefer to visit a site in person. Unfortunately, he says, "our bodies just can't be every place that we want to be." So by combining robotics with a few tricks from the VR community, NASA researchers have invented the Telepresence Remotely Operated Vehicle, a robot that brings its operators along through telepresence. Last year Andersen and his colleagues from Ames used the TROV to dive beneath Mc-

You'll Love L.A.

A recent virtual reality trade show in San Jose broke open a closely guarded military secret. Flight simulators are fun. Of the 60 exhibits by VR firms from all over the world showcasing their latest ideas for virtual entertainment, the biggest hit by far was the "ride" offered by Evans & Sutherland, a Salt Lake City firm that builds pilot training simulators for the airlines and the military. Specialists in virtual flight—the company also supplied NASA with a VR simulator to train astronauts for the Hubble Space Telescope repair mission—Evans & Sutherland introduced the Virtual Glider to see how its simulations would play in the consumer market. And judging from the hordes of people that did everything but trample one another for a chance to ride, they played pretty well.

Pilots of the Virtual Glider experience the sensation of flight by hang gliding amid the towering skyscrapers of what is meant to be 21st century Los Angeles. They experience the blur of flying cars whizzing by, the thrill of plummeting thousands of feet in mere seconds, and the occasional midair collision with an unfortunately placed edifice.

Undoubtedly, much of the illusion's success is rooted in the Glider's imaginative interface. Instead of using the typical VR headmount, riders are strapped horizontally into a hang glider harness in preparation for the journey. They don't use a mouse or a joystick but a hang glider steering bar to maneuver through the cityscape. And to complete the feeling of total immersion, there's a conveniently adjustable visor that riders look through to navigate the world of 2025 L.A.

Initially, there's a mild feeling of euphoria as you and your hang glider are launched into the three-dimensional world of cartoon-like

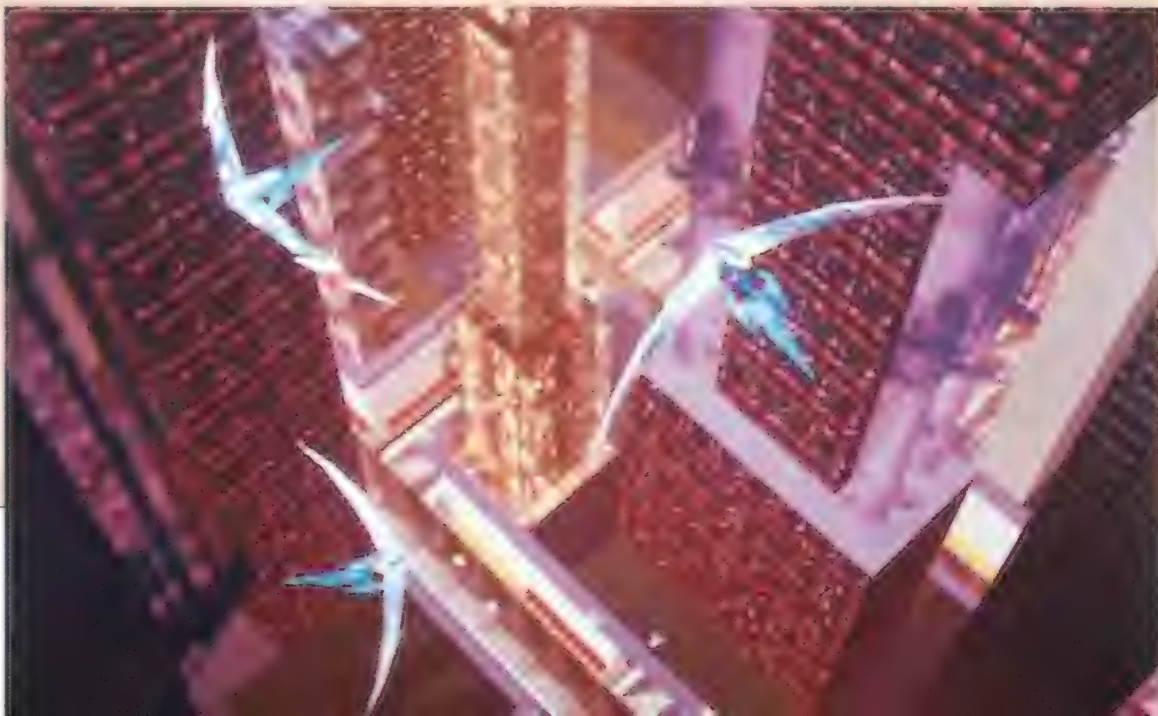
buildings and streets, and you gently float amid the lavenders, grays, and browns of a future Los Angeles. But as soon as you get your first taste of a midair collision with a skyscraper—thoughtfully accompanied by the sounds of shattering glass—the survival instinct kicks in, and you and the Virtual Glider's steering bar become quick friends.

The most impressive part of the ride is that no two flights are alike. Although they each last two minutes, the rider can choose—by twisting and turning the bar—to zigzag among the lofty tops of the city's tallest structures, play dodge-'em games with futuristic industrial buildings, or swoop down for a daredevil ride along the city's sidewalks.

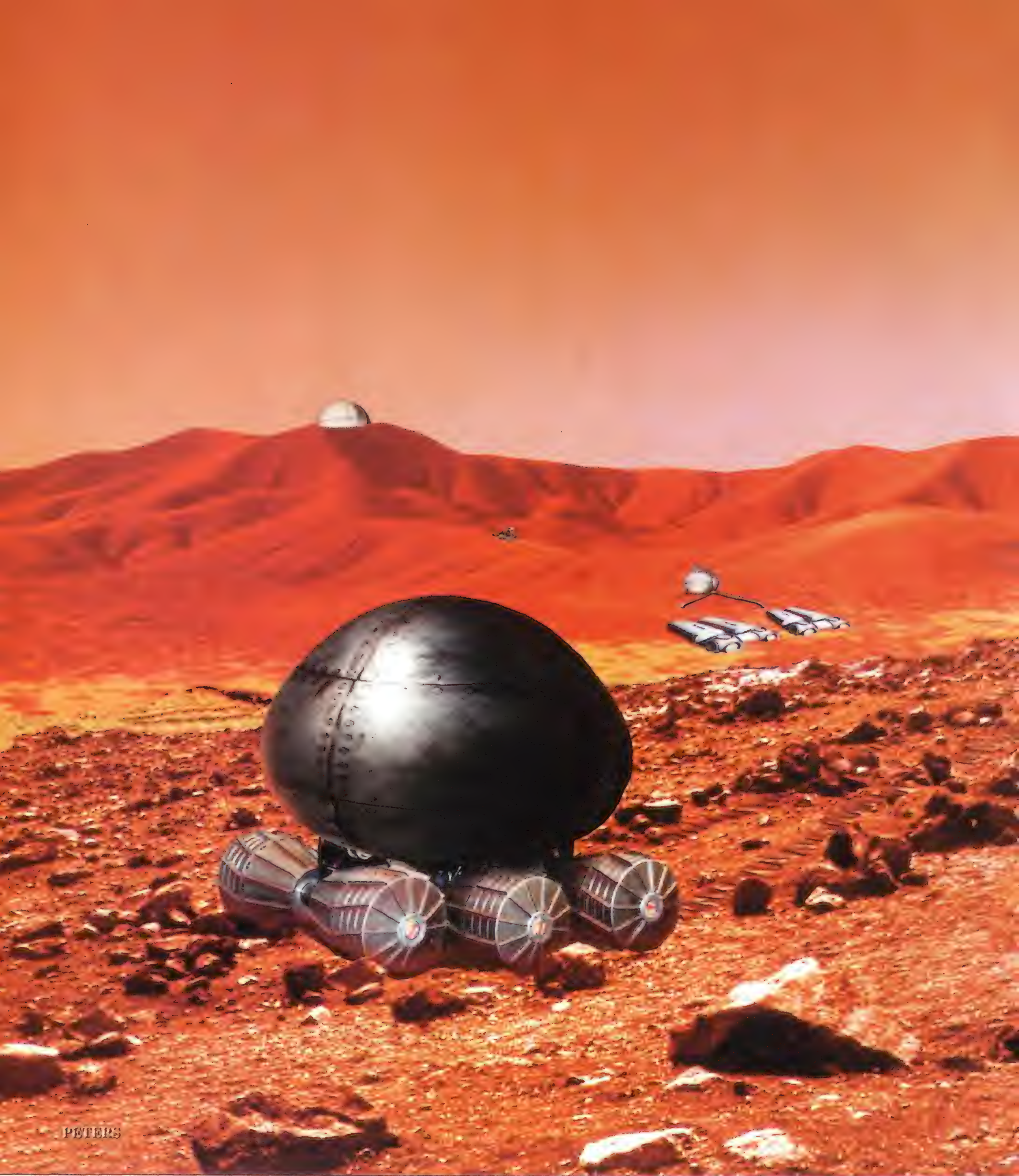
The makers of the Virtual Glider say the secret behind its life-like feel is power. Evans & Sutherland builds its own hardware—an ESIG-2000 image generator—to create its virtual worlds. And according to business manager Jeff Edwards, this makes all the difference. "It's easy enough to build a gorgeous 3-D world on your PC," Edwards says. "But in most cases it will take a long time to render just a single frame." In contrast, Edwards says, Evans & Sutherland technology generates new 3-D images 30 times every second.

Ironically, even though the Virtual Glider continues to draw crowds at trade shows, Edwards says the company has no intention of marketing the exhibit as a product. Instead, Evans & Sutherland is planning an even more advanced VR experience to debut later this year. Predictably, Edwards is mum about the specifics. But he does give an indication of what to expect. "Hang onto your shorts," he says.

—Joe Dysart



EVANS & SUTHERLAND



PETERS



Murdo Sound to depths that their bodies couldn't reach.

The TROV is equipped with stereoscopic cameras and a robotic manipulator arm, which together act as extensions of the operator's own eyes and hands. The beauty of telepresence is that the operator can be practically anywhere. During last year's tests, the TROV was driven at different times by the NASA team in Antarctica, their colleagues in San Francisco, and school children in Washington, D.C. All they needed was a computer connected to the Internet, a mouse or other device for sending commands, and a pair of 3-D glasses for stereo vision (not essential, but helpful for grasping objects).

The TROV could be seen as just the latest in NASA's long line of remotely operated explorers. The Voyager spacecraft, after all, are controlled by radio signal from billions of miles away. But the combination of VR and advanced telerobots promises something truly revolutionary. A Mars rover equipped with high-resolution cameras and a laser ranger, for example, could use the ranger to construct a 3-D computer model of the terrain around it, then superimpose the camera images on top of that model, like putting clothes on a wire dressmaker's model. The result would be a very-high-fidelity simulation of the surface of Mars. The simulation could be stored on disk and made available for anyone, anytime, to explore at leisure through VR.

This technique offers another great advantage. Tele-operations on Mars have always been considered impractical because of the 20-minute signal delay between the time a command is given here and the time it is received there. But VR "buffering" gets around the problem by having the operators on Earth do all the "navigating" in a virtual world that exactly duplicates the terrain around the rover. They would then relay the navigation instructions to the real rover, which would have enough onboard intelligence to get out of spot jams. It wouldn't be telepresence, strictly speaking, in that it wouldn't happen in real time. But it would work around the communication gap.

Butler Hine of Ames just tested a prototype of this kind of VR system, which he designed for NASA's eight-legged telerobot and volcano explorer, Dante. After Dante failed during a 1993 mission at Mt. Erebus, Antarctica, son of

Dante successfully climbed more than 600 feet into the crater of Alaska's active volcano Mt. Spurr last summer. Dante II trudged around in the muck on its own, and, when the going got really rough, waited patiently while operators wearing stereo goggles looked for holes or other potential trip-ups in the environment that Hine's system created using data from Dante's camera and laser scanner. Dante got caught in a mudslide but completed the mission.

Now add 10 years of improvement in VR displays and robotics technology, and for Mars substitute the surface of Pluto, or the Uranian moon Miranda, or some other place where no human is ever likely to go, and suddenly we're talking about the possibility of real, honest-to-God, virtual space travel. "Our near-term goal is to put this capability on researchers' desks around the country," Hine says.

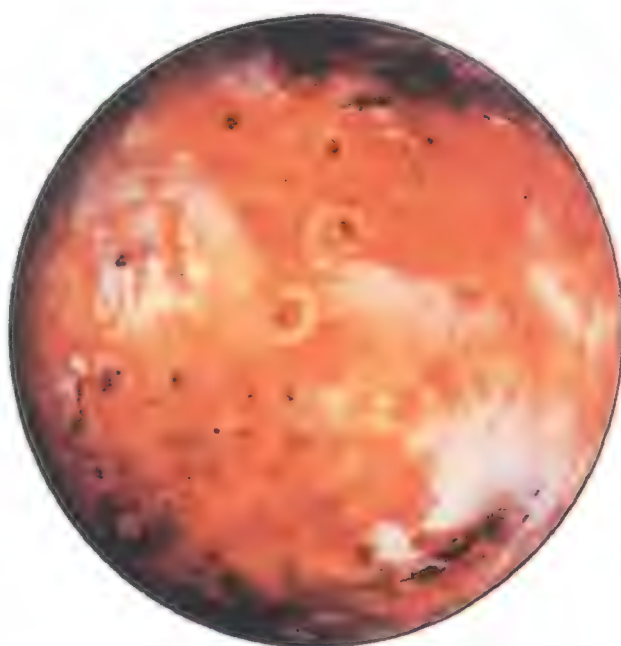
Former astronaut Dave Scott has the same goal for his two-pound robot, called Grendel (named after the monster in *Beowulf*). Scott, who did geological field work on the moon during the Apollo 15 mission and later started his own company, Scott Science and Technology, is working with several old friends from the Apollo days and colleagues at MIT and Brown University on a plan to send a whole fleet of Grendels, sensor- and camera-equipped micro-rovers, to the moon. Grendel, he explains, has already been "trained" to do the kind of photo-documentation Scott did on the moon almost 25 years ago. In trials, the robot was able to select a rock with an infrared seeker, stop in front of it, take a picture, step to the side for a stereo view (just as the Apollo astronauts did), pan the scene to identify the rock's surroundings, then head back to home base. All by itself.

Scott believes that Grendel could accomplish one thing that he and his fellow astronauts were never able to do: get the reality of lunar exploration across to the public. "We were never able to describe it adequately," he says. "We used words like 'mind-boggling,' whatever that means." With today's technology, he adds, you could send high-quality images back, then let people "sit in an IMAX theater, give 'em a cup of coffee, and just let 'em enjoy it."

If Grendel and friends ever make it

to the lunar surface, they may have company. Last February, LunaCorp, an outfit in Arlington, Virginia, announced plans to send a desk-size rover to the moon in 1997 to explore the Apollo 11 landing site and other "historic" areas. Perhaps the most significant thing about the project is that LunaCorp isn't seeking NASA funding. Instead, it hopes that TV networks and theme park owners like Disney will foot most of the \$120 million bill, in exchange for letting their customers drive the rover around on the lunar surface. LunaCorp president David Gump says theirs is "the first attempt to let the public participate in space exploration."

LunaCorp's robot will be built by a team led by Red Whittaker of Carnegie



Mellon University, which built the Dante robot for NASA (see "Getting Around on Mars," June/July 1991). Even though there are real technical hurdles to surmount when operating on the moon—reliable power and communications links, to name only two—none is beyond the reach of current technology.

But LunaCorp's business plan depends on a joint venture with a Russian design bureau, which will provide the launch and landing vehicle. And it's not clear that a Disney-style theme park would ever be able to make live lunar tele-operation pay for itself. How many people will pay to drive a rover across a flat stretch of gray moonscape for five minutes? Would they pay instead to have their own VR simulation based on data from the rover so it would seem as if they were on the moon? LunaCorp

is looking at both options, but the market is still untested.

LunaCorp also would sell rover time to scientists, who presumably would have more than joyriding on their minds. But the company will have to overcome the belief held by some that VR will never be a substitute for going there. Paul Spudis, a planetary geologist with the Lunar and Planetary Institute in Houston, was once convinced, like Dave Scott, that telepresence would be an economical alternative to sending flesh-and-blood scientists to the moon. But having seen for himself the sorry state of current VR technology, he's not so sure anymore. "The more I looked into it, the less comfortable I was with it," he says. "My contention is that you'll never be able to look at this as a replacement for people."

Before debating the value of human presence versus telepresence, says Mike McGreevy, we should try to determine what "presence" means for a field scientist. Toward that end, he has tagged along with geologists in the field, watching their every movement, trying to analyze dispassionately their claim that to really understand a site, they have to go there in person. Eventually he hopes these ethnographic studies, which he is just beginning, will determine what sensory experience and the experience of scale and direction contribute to scientific research. So far it's impossible to make a judgment. "It might be very hard to prove that [human] presence is essential," he says. "But first of all, let's find out what it is."

All this talk about robots-instead-of-humans makes some people nervous, of course. They fear that VR addiction will turn us into a race of planet-potatoes, afraid to move off our duffs and out into the solar system. McGreevy himself is uncomfortable with the idea of a space program for shut-ins and says that humans and robots will always explore together. He says, "If we ever degenerate into a world of virtual explorers, where no one ever actually saw a real volcano and just logged into one over the Net, we're in big trouble."

Then again, if the same billions needed for human planetary exploration were invested in VR research, we might reach a point where we couldn't tell the difference. —

This year, give the gift of spellbinding action and discovery!

A gift of *AIR & SPACE/Smithsonian* is one that definitely won't end up on some forgotten shelf.

Every issue of this big, one-of-a-kind magazine comes brimming with vividly authentic adventures into the realm of flight and the mysteries of space!

The official publication of the Smithsonian's renowned National Air and Space Museum, *AIR & SPACE/Smithsonian* is a feast for both the eye and mind.

Every feature a strikingly graphic presentation!

No other magazine affords such realistic visits to the exciting world of pilots, astronauts, and aerospace scientists—such vividly stirring adventures to the highest frontiers.

AIR & SPACE/Smithsonian re-creates for those to whom you give it the epic flights of famed air and space craft of every type, every era. It even details how man will one day explore other worlds and reach out for contact with alien intelligence.

More than a subscription—a multi-part gift!

When you give *AIR & SPACE/Smithsonian*, you also give membership in the National Air and Space Museum at no extra cost!

With benefits like discounts on flight-related and other merchandise, and eligibility for exciting events scheduled throughout the nation by the Museum, as well as by the Smithsonian itself, membership alone would make for an exciting gift.

How to give all this, and save money too!

A gift of *AIR & SPACE/Smithsonian*, including Museum membership and benefits, actually costs substantially less than the newsstand rate for the magazine by itself.

In short, it's not only a genuinely attention-getting remembrance, it's a very affordable one as well.

Send your favorite people this uncommon multi-part gift simply by completing and returning the coupon. We'll bill you later.

NOTE: ORDER YOUR GIFT SUBSCRIPTION NOW! To assure timely delivery, we must receive your order as quickly as possible.



To Mars and Beyond

When people travel to other planets, what will they have under their feet?

L

When people travel to other planets, what will they have under their feet? The answer is not as simple as it seems. The first step is to find a planet that is habitable. This means a planet that has liquid water, a breathable atmosphere, and a temperature range that allows for life. Mars is one of the most likely candidates for this. It has water ice at the poles, a thin atmosphere, and a temperature range that is not too far from Earth's. However, there are still many questions about Mars that need to be answered before we can send people there. For example, we need to know if there is any life on Mars, and if so, what kind of life it is. We also need to know if Mars has the resources we need to survive there, such as food and water. Until we have the answers to these questions, we cannot send people to Mars. But the dream of going to Mars is still a powerful one, and it is one that we should continue to pursue.

Use this form to order your gift subscription today!

AIR & SPACE

Smithsonian

HOLIDAY GIFT ORDER FORM

Please enter the person named below as a subscriber to *AIR & SPACE/Smithsonian* for six bi-monthly issues—and as a member of the National Air and Space Museum for one year.

Gift To:

Your name and address here:

NAME

MY NAME

ADDRESS

ADDRESS

CITY

STATE

ZIP

CITY

STATE

ZIP

☐ Bill me

☐ Payment enclosed

☐ Enter a subscription for me

MY TOTAL ORDER: _____ gift subscription-memberships (including my own if checked above) at \$18 each total \$_____.

NOTE: Outside USA add \$6 for each foreign order. Payment must be made in U.S. funds. (85% of dues is designated for magazine subscription.)

MAIL TO: AIR & SPACE/Smithsonian, P.O. Box 53261, Boulder, CO 80322-3261

2CHG9

The Skies, the Limits

World War II was winding down, but for a group of international delegates meeting in Chicago, the battle for international air rights had just begun.



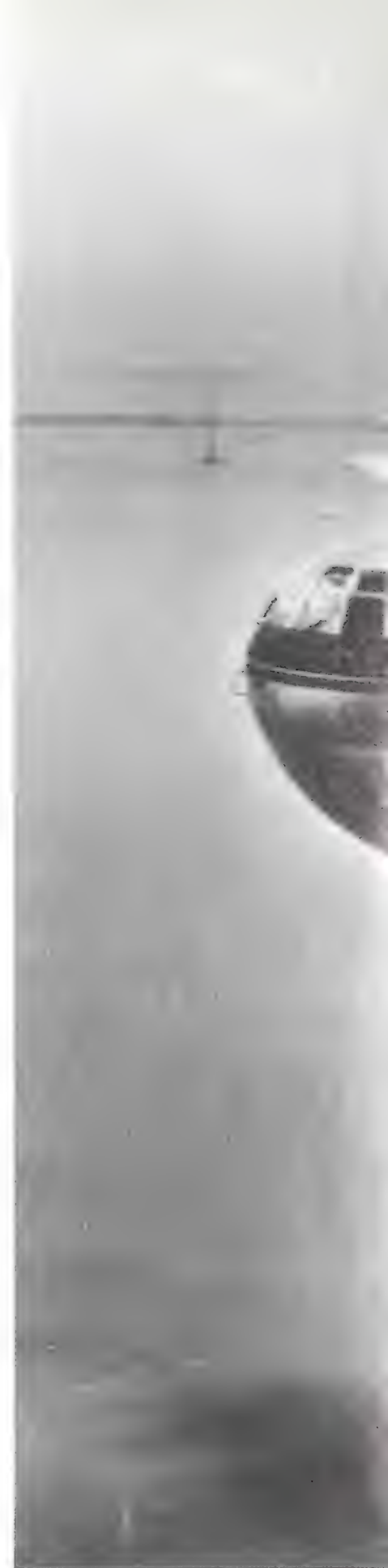
NASIM (2)

Even in the midst of war, it was clear a new world was coming, as an American Airlines brochure promised in 1943 (left). Before long, airliners like the luxurious Boeing Stratocruiser (right) would be carrying passengers on burgeoning international air routes—but only after the world's nations decided who had the right to claim access to those routes.

by Henry Scammell

LWelch Pogue was born in the tiny town of Grant, Iowa, on the cusp of the 19th century, when William McKinley was president of the United States and Victoria was queen of England. If, from today's perspective, the tide of human events at that time appears to have been at an ebb, back then there was a powerful, more accurate sense, especially in America, that the waters of history were gathering to an unprecedented flood. Pogue, who was the son, grandson, and great-grandson of Midwestern farmers, belonged to the only generation of Americans with a prospect that a handful of its members' lives would traverse the coming tumult to link three centuries and see a new millennium.

At the age of 10 weeks, the baby Pogue entered the second of those three centuries. In faraway southern Africa, the Boer war was stalemated at the siege of Mafeking, and on the other side of the clock a new siege on Peking was just





beginning with the Boxer uprising. Both events engaged the public consciousness as aspects of the contest between the rulers and the ruled. But equally significant were the terrible distances involved; the passage to China or the Transvaal by land and sea was measured in months, and frequently beset with mortal risk.

Much nearer to home, landmarks of a different sort were emerging. On one side of Iowa, temperance crusader Carrie Nation was raising a siege against the thirsty farmers and wicked saloonkeepers of Kansas. And in the opposite direction, at their small shop in Ohio, bicycle builders Wilbur and Orville Wright were beginning experiments with kites and gliders that would soon rewrite the age-old relationship of time and space.

Man's first powered heavier-than-air flight lifted Orville Wright above the coastal dunes of North Carolina on De-

cember 17, 1903. The initial try went 120 feet and took just 12 seconds; the fourth attempt that same day lasted five times longer and went seven times farther, a learning curve that would set a pattern for the growth of aviation over the coming decades. Welch Pogue was only four at the time and half a continent away, but 13 years later, and in the most unlikely manner, his own life took a sudden turn that would eventually converge with what had begun at Kitty Hawk.

It happened in the courthouse at Red Oak, Iowa, during the famous Villisca murder trial, the biggest event in southwest Iowa since the Mesozoic. Eight people had been slaughtered with an axe and the case was being argued by legal heavyweights brought in from Chicago. Young Welch attended the trial every day after school, not because he was titillated by the accounts of carnage but because he was fascinated with the style, eloquence, and learning of the bat-

ting attorneys. By the time it was over his own future was sealed as finally as the defendant's: he had lost any inclinations that may have lingered from his ancestry in farming and had decided on a career in law.

If the history of civil aviation has a shape, it might be that of a funnel, starting at Kitty Hawk and flaring dramatically outward at the end of World War II. The International Civil Aviation Conference held in Chicago in the fall of 1944, just before that sudden expansion, signalled the mood that preceded the coming peace. It was a time of high anticipation, not only for the rechanneling to civilian use of technology and the vast production capacity developed during the war, but for the start of a new era of worldwide openness, reunification, and healing. Although the conference had been convened by the United States for the purpose of achieving a general agreement on international air and landing rights and forming an international body to control global aviation after the war, the issue that set its theme and captured the public imagination was "Freedom of the Skies."

It was familiar language. When President Franklin Delano Roosevelt had given his annual address to Congress on January 6, 1941, his main focus was on the European war, which America had not yet entered, and support of the lend-lease program for aid to Britain that he had introduced a month before. But the message that gave the speech its place in history was what Roosevelt said at the end about his vision for the future. The "Four Freedoms"—freedom of speech and worship, freedom from want and fear—would define America's purpose throughout the coming years of conflict. For many Americans, they were virtually indistinguishable from the Bill of Rights.

Artist Norman Rockwell's 1943 illustrations of those four freedoms for the *Saturday Evening Post* were to become among the most famous paintings in history; they attracted requests for millions of reprints, were made into posters for promoting bond drives, and were displayed in public buildings, meeting places, and homes throughout the country. Now, on the eve of victory, freedom of the skies was a calculated echo of that early promise.

It was also an echo of another concept, equally the subject of much hope and contention in prior days: freedom of the seas. The biggest obvious difference was that the sovereignty of coastal nations was still considered absolute where the water ended, while there was serious division on whether nations should yield their sovereignty over their airspace as if the sky, with its lack of distinct boundaries, belonged to everyone.

By the time of the Chicago conference, the airline industry, for all intents, was still in its early twenties. Up to then, much of the Third World, as it was later called, was still in the grip of colonialism, and the issue of who owned various

rights of passage, especially over long-distance routes, was as often negotiated between empires as between independent countries. The history of Dutch airline KLM's route to the Dutch East Indies, for example, was mainly one of haggling and strained accommodations with the British, who controlled the territories and airports throughout the Middle East, India, and Malaysia. The British were tough, oppositional, and sometimes capricious, but later, in a classic case of the biter being bitten, when they started building stepping stones of their own to Singapore and Australia, they were forced to negotiate a quid pro quo for at least two stops in the Dutch East Indies, now Indonesia, which linked the Indian and Pacific oceans.

The competition for traffic over those routes took some strange turns. In the mid-1930s the Dutch gained an important lead with their acquisition of the Douglas DC-2, the revolutionary transport that had astonished the aviation world



Automobiles were still curiosities when six-year-old L. Welch Pogue (with his parents) tentatively gripped the wheel of one at the 1905 Iowa State Fair. By the time he was in his mid-40s, Pogue had become comfortable with the next generation of transportation technology, as chairman of the CAB (opposite).

by placing second against racing planes in the England-Australia air race. The British were still using a grab bag of comparative antiques, starting with a huge 38-seat biplane, the comfortable but slow Handley Page H.P.42, on the leg from London to Paris or Zurich. But politics were as much a handicap as technology. At one point, because Italy would not grant Britain the right to operate in its airspace, passengers flying to Africa or Asia on Britain's Imperial Airways had to deplane at Paris, take a train to Brindisi in southern Italy, and catch a flying boat across the Mediterranean to Cairo; they transferred to a de Havilland D.H.66 landplane for the trip across the eastern Sahara, then to an Armstrong Whitworth Atalanta in Basra, Iraq. In 1937 Imperial Airways start-



Pogue saw a tremendous future in aviation, though it's little in evidence in a preternaturally calm scene at New York's new La Guardia airport in the early 1940s.

ed using the famous Short S.23 Empire flying boats, ordered off the drawing board in 1934. But by then a lot of English businessmen with tin mines in Malaysia or trading interests in Singapore had acquired the habit of just flying to Amsterdam and taking KLM's DC-2 instead. It was an expensive lesson, and one the British would not soon forget.

Except for the *Hindenburg* in 1936, regular transatlantic air service had not begun until 1939, three years after Pan American began carrying passengers on its flying boats across the Pacific and just a few months before the Battle of Britain. But transatlantic air travel didn't gain wide acceptance until the first months after the U.S. entered the war, when thousands of Allied lives were lost to German U-boats right off the North American coast. At that terrible price, the submarines helped change the public's attitude toward flying: what had long been held as fearful was now seen as comparatively safe.

In 1944 the United States invited 55 friendly nations to the International Civil Aviation Conference; all but two attended. The Russian delegation got about halfway to Chicago before turning back without explanation, and the Saudi Ara-

bians never started. The American team of 10 was headed by Assistant Secretary of State Adolf Berle, who was elected conference president. It also included two senators, two congressmen, polar explorer Admiral Richard E. Byrd, New York mayor Fiorello H. La Guardia, an assistant secretary of commerce, and the vice chairman and chairman of the Civil Aeronautics Board. The CAB had been created by the Civil Aeronautics Act of 1938. Its chairman was a 45-year-old attorney from Iowa by way of Massachusetts, Paris, France, and New York City—L. Welch Pogue.

Pogue had become involved with airlines when, as a Wall Street lawyer, he helped to handle registration of the first aviation securities following the Securities Act of 1933. Convinced he had seen the future and that it had wings, he applied for a position in the legal department of the newly created Civil Aeronautics Authority, as the body was then known. He was named assistant general counsel on his second day and succeeded his boss just a year later. In January 1942, President Roosevelt designated him chairman, a post he held for six years.

Although this meeting was held on U.S. soil and involved





only U.S. allies, it soon became apparent that the participants were using it to define and protect their nationalistic interests, and those interests diverged widely. Just how widely became apparent on November 1, when, almost at the opening bell, Adolf Berle began trading jabs with Lord Swinton, his counterpart from Britain, America's closest wartime ally.

Berle (pronounced "burly") was slight of build and stature but compensated with an aloof, often bristly personality, great power as a speaker, a formidable intellect, and a patrician disregard for details. A more obvious choice to head up the U.S. contingent might have been Under Secretary of State Edward Stettinius, who normally dealt with international civil air matters. But Stettinius' sister was married to Juan Trippe, whose Pan American Airways had long considered itself the "Chosen Instrument" of U.S. foreign policy. Up to a point it had made sense for the United States to do much of its negotiating abroad through such commercial entities as Pan American and the United Fruit Company, but with the new internationalism emerging from the war it was becoming apparent that the country's political and busi-

ness interests did not necessarily run parallel. But even though Trippe was not physically in Chicago in 1944, his interests were clearly at stake, and there was a strong sense of his presence metaphorically prowling the tall grass at the perimeter of the Stevens Hotel, the conference site on Lake Michigan. At the start of the war, Pan American had been one of only 10 airlines operating intercontinentally, one of only three with anything like a world network (Britain's Imperial Airways served five continents, mostly with flying boats, and Air France served four), and the only American flag carrier in either category. The assignment of the job to Berle over Stettinius, therefore, represented an effort to keep Trippe's influence in check.

Lord Swinton had been prominent in British politics for

The British worried about a post-war world dominated by American transports like the DC-4 (right), which flew in the war as the C-54. A 1944 McDonnell Aircraft ad (opposite, bottom) anticipates the DC-4's more glamorous future.



In 1944, representatives of 54 nations gathered in Chicago to wrestle over the world's air transport future (opposite).

A bevy of smiling hostesses welcomes a newly arrived Bolivian delegate to the conference (right).

more than 20 years and had been one of those responsible for preparing the Royal Air Force before the Battle of Britain. He was on a diplomatic mission to West Africa when he was given charge of a new Air Ministry, and just 26 days later he was in Chicago. That meant that in less than four weeks Swinton had to finish off whatever he was doing in Africa, undergo intensive briefing in London, huddle with delegates from the Commonwealth nations at a pre-conference gathering in Montreal, and arrive in Chicago with his shirttail tucked in. The shirt stayed starched and anchored even after his collision with Adolf Berle.

The conflict had as much to do with personalities as with issues: from their first meeting the two men took a dislike to each other, and it was downhill from there. Swinton was notably self-possessed, and Berle was hardly shy. But a major factor was the same take-it-or-leave-it negotiating style the British had used with the Dutch a decade earlier, inappropriate in these new circumstances and fundamentally at odds with the Americans' more traditional give-and-take. Swinton's trial balloons were presented as armored dirigibles, with no apparent latitude for bargaining.

Berle began the conference by describing the air, like the sea, as "a highway given by nature to all men," and he cautioned against "the denial of equal opportunity for intercourse [which in earlier days] made the sea a battleground instead of a highway." The conflict on the issues behind those idealistic-sounding words soon reached crisis proportions.

Welch Pogue's experience in the law had taught him to look behind polemics for the alternating threads of pragmatism and self-interest that run through the fabric of any political discourse, and from his perspective as head of the CAB he had no trouble identifying the pattern of the cloth in Chicago. America was romancing the concept of "open skies" for the same reason Britain and the other conferees opposed it: of all the major players at the dawn of intercontinental air transport, the United States was virtually alone in being able to take full and immediate advantage of its commercial opportunities by the war's end.

The United States owed its advantage in large measure to the war: Britain, facing a savage battle with the Luftwaffe, was concentrating on producing such short-range tactical aircraft as the Spitfire and Hurricane and small, light night bombers, while America was producing the long-range transports and heavy daytime bombers capable of crossing the Atlantic and the Pacific. This situation served Britain well enough while Canada and the United States were supplying food, materiel, and ferry service across the long reach of ocean. It would be another matter when, at the war's end, they faced each other as potential economic rivals, with well over 90 percent of the world's commercial transport airplanes and almost all of its manufacturing capacity on the Ameri-



BETTMANN ARCHIVE

can side of the bargaining table.

As an alternative to a free-for-all, which they were unlikely to win, the British floated the concept of a kind of international CAB. Its function would be similar to the organization for U.S. domestic operations chaired by Pogue: it would determine international routes, who should operate them, and what their schedules should be, and would also regulate competition. But if that leveled the playing field at one end, it tilted it unacceptably against the United States at the other. The U.S. was not about to agree to a system that, aside from neutralizing the huge advantage of its early lead, would subject international air traffic to a majority vote by foreigners certain to gang up against it.

Soon after the conference started it came to an effective stop for 10 days while the United States, Britain, and Canada caucused separately in an attempt to reconcile these fundamental differences. Swinton's problem was not only with the U.S.; in some important particulars Canada's conference agenda was very different from Britain's, and his earlier meet-



AMERICAN AVIATION MAGAZINE

When London to Washington, *Non-Stop*
...becomes just a Routine Flight

ing with the Commonwealth nations in Montreal had failed to produce the unanimity he was seeking.

Unlike the United States and Britain, Canada knew that with only a tenth the population of the United States it would never be as prominent a generator of transatlantic traffic. But for the next several years at least, most commercial aircraft would lack the capacity for Europe-U.S. non-stop Atlantic crossings, and Canada's main bargaining chips were its stepping stones for fueling and maintenance in the Maritimes. It was becoming clear that freedom of the skies meant different things to different countries, depending on what they had at stake.

In fact, what it came down to was "Five Freedoms," although it might have been more realistic, if less politic, to call them the "Five Restrictions." All five, describing different stages of liberalization of flying rights, were refined and made explicit in Chicago and survive today.

The first freedom is the right of a civilian aircraft to fly through another country's airspace. (The right to fly above the oceans is a natural extension of freedom of the seas.)

The second freedom is the right to land in a foreign country for technical or operational reasons, such as refueling or an emergency.

The third freedom is the right to transport traffic by aircraft from the carrier's country to another country, and the fourth is the reverse. An example of third freedom traffic would be United Airlines picking up an American passenger in New York and carrying him to London; the fourth freedom would be Northwest picking up a British passenger in London and bringing him to New York.

The fifth freedom is for traffic between two countries other than the carrier's. An example of its simplest form would be United Airlines picking up a passenger in London and carrying him to Frankfurt. In a slightly more complex variation known unofficially as the sixth freedom, KLM might



From the earliest moments of the conference, Britain's Lord Swinton (above) and the U.S.'s Adolf Berle (opposite) squared off as opponents. The source of contention was the innocuous-sounding "Five Freedoms of the Air," which categorized international flying rights (opposite, right).

pick up a passenger in New York, stop in Amsterdam, then fly him on to Frankfurt.

There is also cabotage, which predates any of the above and is not defined as a freedom of the sky. Cabotage is the right of a foreign carrier—originally a coastal freighter—to carry paying traffic between two points within the same country; a 19th century English barkentine, for example, might have negotiated the cabotage for service between Cherbourg and Le Havre. In aviation, cabotage was more frequent in the earliest days of flight, when the nation being served may not have had its own airline; today, it is an extreme rarity.

Fifth freedom traffic was the focus of the greatest concern by the British because of all the freedoms it intrudes furthest into a host nation's economic sovereignty. Indeed, Welch Pogue suspected that the various freedoms came to be classified the way they were specifically to isolate fifth freedom traffic, all the better to control it and check the growth of the United States' international air routes.

As in any diplomatic negotiation, many of the signals during the Chicago conference were called from far off stage. Franklin Roosevelt and Winston Churchill spoke several times by telephone during the conference, the former to



PROVEN IN WAR — FOR PEACETIME PERFORMANCE

Three DC-3s and a DC-2 await passengers in a wartime scene at La Guardia (opposite). The veteran twin-engine aircraft were still the mainstay of U.S. fleets at the war's end.

The Curtiss company looked forward to peacetime use of its C-46 Commando (left); the transport would have only limited use as an airliner, however.

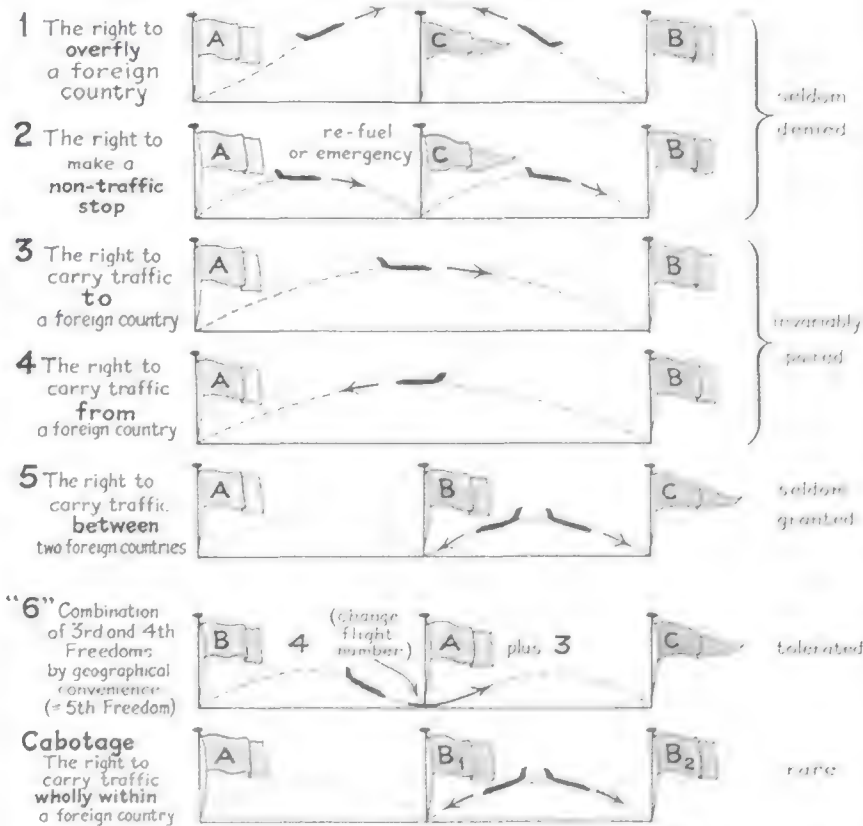


defend the concept of open skies as an ideology, the latter to argue against it as economic aggression. But it was one thing for the prime minister to deal at parity with the president of the United States, and quite another for Churchill to communicate with his troops in the field at Chicago. All of Swinton's orders from home were funneled to him from a command center in London presided over by Lord Beaverbrook, a dynamic newspaper owner and the minister of aircraft production.

Midway through the conference, the issue of whether Britain would grant fifth freedom traffic to Commonwealth countries became a major sticking point, so at the same time Swinton remained as adamant as ever at the negotiating table, he queried the home office on whether his handlers might relent. Beaverbrook called back as soon as he saw the re-

THE FIVE FREEDOMS OF THE AIR

(shown as those of originating country A, destination country B, and a third country C)



quest, mid-morning London time, only to have a sleepy, irate Swinton tell him, "Max, go to hell—it's three o'clock in the morning here." Beaverbrook hung up and sent a telegram. When Swinton awoke, he read the decoded message: "On Fifth Freedom, we can grant rights to and from British territories." It was an enormous concession.

When reports began to reach London about the turnaround



in Chicago, however, Beaverbrook got on the phone to Swinton, asking, "Why oh why don't you follow instructions?" Swinton didn't understand and referred to the cable. Beaverbrook was aghast, and after a quick consultation with his committee in London advised Swinton that a key word had been omitted in decoding; the word was "not." Ever the good soldier, Swinton picked up where he had left off before the cable had arrived, and when a perplexed American team noted yet another reversal, the British delegation denied everything, insisting their position had not changed.

At the time of the Chicago conference, Juan Trippe doubtless recognized that rejection of fifth freedom rights would mean largely a return to pre-war business as usual; for an expansion-minded airline like Pan American that would mean nearly continuous involvement in time-consuming, troublesome, and expensive bilateral negotiations. And the larger a carrier's international route system, the more dependent the airline becomes on fifth freedom business.

That would be borne out by Pan American's own experience just a few years later, in the 1950s, when it declared itself the "Round the World Airline." When PAA Flight 1 took off from Idlewild airport in New York, almost all of the passengers on the initial leg from the United States to London would be third or fourth freedom traffic. But by the time the Lockheed Constellation reached Karachi or Calcutta, the ratio would have reversed, with the majority of traffic local to the area served. How much simpler for Pan American if the rights to that traffic were mandated by multilateral agreement, rather than negotiated painfully and politically case by case.

But it was not to be. After spending much of the month-long conference in bitter debate largely over fifth freedom rights, the conferees adopted the International Air Services Transit Agreement, which recognized the first two freedoms alone. As is true today, the remaining three would have to be secured country by country through bilateral agreements.

At the time the conference ended, there were conflicting views in the United States on what it had really accomplished. "There were those who felt the Conference had failed," Pogue wrote later. "There were those who felt that it was on the verge of a grand and glorious success if but a last push of skillful effort could be applied. And there were those who felt that enough success had been achieved, and that it was time to adjourn."

Pogue placed himself in that third group, and he left Chicago recalling the words of his brother-in-law, Harold Edger-



As predicted, a strong air transport industry emerged after the war; in 1946, under the appreciative smile of CAB chairman L. Welch Pogue, president Harry Truman signed a bill designed to provide the nation with 3,000 new airports. The elegant Lockheed Constellation (below) helped usher in this new era.

ton, an MIT professor who developed equipment for high-speed photography. "Well, we learned something from that one," Edgerton would say in the wake of an experiment that did not turn out as planned; "that is not the way to do it." By dropping without a vote all discussion of the loosely held notions about freedom of the air, the conference proved to the world that the concept of open skies was no match for national claims of sovereignty.

What was accomplished, however, has proven durable. Article One of the Convention on Inter-

national Civil Aviation, the set of rules governing post-war international aviation that emerged from the conference, reads, "The contracting States recognize that every State has complete and exclusive sovereignty over the airspace above its territory." The Convention is in effect today with 183 contracting states.

The International Civil Aviation Organization created by that Convention is headquartered in Montreal and is affiliated with the United Nations. Its principal mission is the promotion of aviation safety and technical progress in such areas as navigation standards and practices, security, technical cooperation, and aviation law. Although it has developed some model clauses for bilateral agreements, it is strictly a consultant and plays no direct role in the negotiations by which its member nations still barter between themselves for Freedoms Three through Five. But even today, 50 years after Chicago, the nearly theological issues that aroused such fervor and division at ICAO's birth can still produce similar degrees of hope and suspicion, amity and rancor, militant



nationalism and blue-sky idealism.

And much of the same old language. In January of this year, the *Washington Post* quoted an unnamed official of the British embassy on the increasingly contentious issue of improving American carriers' access to London's Heathrow airport. The diplomat said Britain "envisaged a staged approach to full open skies...but it has to be done sensibly in a balanced and phased way." But, as if to distinguish between times past and present, he said the British position "was put forward as a basis for negotiation and certainly was not a simple ultimatum."

Not all the jockeying for market share is taking place in multilateral negotiations over the five freedoms. Some foreign airlines have found new ways of globalizing their networks through "code sharing" relationships like the one between Lufthansa and United Airlines which allows United to act as an agent of Lufthansa and circumvent some European restrictions on entry. But British Airways, KLM, Swissair, Singapore Airlines, Air Canada, and possibly (by proxy) Air France have gone much further, buying or bartering partial ownership of such generally troubled partners as USAir, Northwest, Delta, and Continental. Of the 13 largest carriers in the world, seven are American, including the top three—and including the four carriers named above. As one longtime observer puts it, the foreign carriers "don't buy in because it's a good investment in terms of money or because they're trying to help us. We have more traffic originations than anyone else in the world, and they're buying control of that traffic. For our government to let this happen is unpatriotic and ridiculous."

That observer is L. Welch Pogue, now 95. Still a frequent visitor to his former law offices in Washington, D.C. (once the second largest in America), and a lively, amiable familiar at the powerful Cosmos Club, he looks toward the approaching millennium with the clear, steady vision that has served him through the adventure of his long, productive life. That prize, along with the newest incarnation of the wily phantom of the open skies, may be just around the corner, but neither one is quite yet at hand.

Marking the 50th anniversary of the Chicago convention, two conferences will be held this fall. The first, in Chicago from October 30 through November 1, has been organized



BREITON LITTLEHALES

At 95, Welch Pogue is still a sharp-eyed observer of the international air transportation scene.

by the McGraw-Hill aviation publishing group to discuss what the next 50 years may hold for the industry. And from November 23 to December 6, in culmination of a decade of preparation, ICAO will host a worldwide conference in Montreal on the present and future of international air transport regulation. Conference planners say it has been called in response to "dramatic changes" toward internationalizing, multilateralizing, liberalizing, privatizing, regionalizing, and globalizing the world's airlines. The words are longer but most of those issues are the same as before, with the less advanced nations meeting under the shadow of megacarriers created by alliances among the dominant players.

Unlike the original Chicago conference, the aim of the Montreal conference is not to form a new treaty but to offer for thoughtful, long-range consideration a "code of conduct" to cover tariffs, pricing, capacity, and services. Such a code could go beyond legislation governing competition and predatory practices, ultimately providing a mechanism to settle disputes. It contemplates, albeit from a reasonably comfortable distance, a major new role for ICAO and a far more open, competitive system for the commercial uses of the highways in the sky.

At both conferences, Welch Pogue will be a featured speaker. ✈

On a Wing and a Paintbrush

REPRODUCED WITH THE PERMISSION OF THE GREENWICH WORKSHOP, INC.



An F-14 soars through sunlit skies in William S. Phillips' "Into the Throne Room of God."

The Art of William S. Phillips: The Glory of Flight. Text by Edwards Park, introduction by Stephen Coonts. Greenwich Workshop, 1994. 172 pp., color reproductions, \$60.00 (hardcover).

At an airshow this summer, a print of one of William Phillips' paintings was on display, hung high on a tent pole. People would walk up to the print, squint, and then, as if feeling the need to explain themselves to the people around them, proclaim, "You know, I knew that wasn't a photograph."

The paintings of aircraft collected in this book all have that quality. When you first lay eyes on them, you see the accuracy of detail, a life-like quality of an image seemingly captured on film. And yet... Sunsets are seldom quite this golden, the clouds hardly ever such a perfect spectrum of pastels, the light on the airplane's flank never quite so perfect, the sensation of speed never quite so real—not even in photographs. And that, of course, is the essence of art.

This book is a blockbuster collection of a great aviation artist's work, presenting more than 80 paintings plus sketches and drawings in black and white. The chapters are organized around a day of flying, though not rigorously so, from "Off at First Light" to "Heading for the Barn."

Each one is prefaced by a text that places the paintings in a context. *Air & Space/Smithsonian* contributor Edwards Park brings the same personal touch to his remembrances that Phillips brings to his painting—they're a kind of publisher's Dream Team. All of it is reproduced in a top-quality volume, on paper heavy enough to notice as you turn the pages.

If you are familiar with Phillips' work, this is all you need to know. If you're not, check out the foldout on page 32 of the June/July 1994 *Air & Space/Smithsonian*. Yessir, genuine Phillips.

—George C. Larson is the editor of *Air & Space/Smithsonian*.

NEW MAGAZINE

CCD Astronomy is dedicated to electronic imaging in astronomy, a field that is growing thanks to new electronic CCD (charge-coupled device) cameras, which plug into computers and make the universe more accessible to both professional and backyard astronomers. One-year subscriptions: \$20.00. *CCD Astronomy*, Sky Publishing, 49 Bay State Road, Cambridge, MA 02138.

The Birth of NASA: The Diary of T. Keith Glennan edited by J.D. Hunley. Introduction by Roger D. Launius. NASA, 1993. 389 pp., b&w photos, \$24.00 (hardcover).

The civilian space program in the Eisenhower administration has seemed an elusive historical target. How are we to make sense of Sputnik, Eisenhower's response, and the early U.S. civilian and military space projects? It is hard to view these events on their own terms, and not through the later romantic, spectacular achievement of landing Americans on the moon. For many, Eisenhower's Republican caution on space seems forever to stand in contrast to Kennedy's Democratic vitality.

The diary of T. Keith Glennan, NASA's first administrator, provides an important corrective to this historical myopia. Glennan's account offers an opportunity to



view the development of the Eisenhower space program on a nearly daily basis. Glennan's tenure as NASA administrator began on October 1, 1958, with the establishment of the agency and continued through the end of the

Eisenhower administration in January 1961. The bulk of the book is a diary account of 1960 and early 1961. This is supplemented by a memoir of 1958 and 1959 events, as well as a reflection on the course of the civilian space program under Kennedy (all prepared in the early 1960s). Glennan's writing combines depictions of his family life and probing insights into the workaday world of Washington.

What emerges from Glennan's account are the tensions and ambiguities of the period, as well as his accomplishments. While the conservatism and restraint of Eisenhower and Glennan are evident, they serve more as a rhetorical backdrop. In the 28 months of Glennan's tenure, the

NASA budget grew by nearly tenfold—a higher rate of increase than occurred during any period of the Kennedy administration. Glennan's shining accomplishment was to manage this rapid increase in NASA personnel and facilities, as well as lay out a long-range program of scientific and human exploration. A foundation for Kennedy's more ambitious agenda was thus cast.

Perhaps the real divide between the 1950s and 1960s lay elsewhere. Under Eisenhower, defense and space spending transformed the economic and social landscape of America, from industry and academia to large and small towns across the country. Eisenhower never fully appreciated how radical this change was. Defense spending was not only a national security policy but a social policy. Kennedy saw the connection, and in it the opportunity to link defense and space spending with other social objectives. Glennan himself stood at this crossroads, embodying the tension between a conservative political philosophy and aggressive military and space spending on behalf of the cold war—spending that changed traditional American institutions and opened the way for Kennedy's New Frontier and Johnson's Great Society.

—Martin J. Collins is a curator in the space history department at the National Air and Space Museum.

NASA HISTORY SERIES

Since 1963 the NASA History Series has published over 60 books, including management, project, center, and general histories, as well as reference works. For more information or a list of titles, contact: NASA History Office, Code ICH, NASA Headquarters, Washington, DC 20546; (202) 358-0384; via e-mail: Rlaunius@codei.hq.nasa.gov.

Richthofen: Beyond the Legend of the Red Baron by Peter Kilduff. John Wiley & Sons, 1993. 256 pp., b&w photos, \$27.95 (hardcover).

The most fabled airman in history flies again, in the pages of noted aviation authority Peter Kilduff's history of Manfred von Richthofen's aerial career. Yet one might well ask, given all the books devoted to the Red Baron, is another one necessary?

Kilduff's work, which refines previous studies of Richthofen, including his own, has much to commend to it. His narrative is detailed and informative. The book's chapters are copiously footnoted, and its appendices include a list of Richthofen's





**PACIFIC
AIRCRAFT**

**HAND CARVED
FROM
SOLID
MAHOGANY**

**World's Leading
Makers of Fine
Aerosculptures**

Carved from mahogany by master craftsmen.
Exquisitely hand painted markings and details.
Size 16" to 22" • Museum quality
Stand included • From \$99.50
Satisfaction Guaranteed

Pacific Aircraft
14255 North 79th Street, Suite 5
Scottsdale, Arizona 85260 • (602)991-1841

**OVER
200
MODELS**

F-14 Tomcat

**CALL (800) 950-9944
FOR CATALOG AND ORDERS**

Get The Best Night's Sleep Ever!



Frustrated With The Quality Of Your Sleep?

Do you toss and turn at night? Can't seem to find a comfortable position? Does your back ache when you awake? These are signs that your mattress doesn't support you properly.

You Control The Firmness

Dual air chambers inside the mattress can each be made firmer or softer so you each get the exact support you want at the touch of a button. No risk 90-night trial and 20-year warranty.



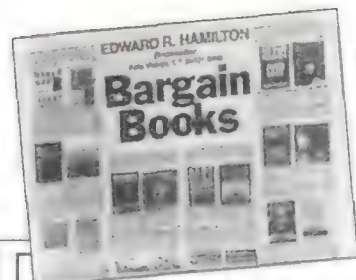
1-800-831-1211

Please send me a FREE Video, Brochure and Price List.

Name _____
Address _____
City _____ State _____
Zip _____ Phone _____

Mail to: Select Comfort Corporation
6105 Trenton Lane N., Minneapolis, MN 55442
© Select Comfort Corp., 1994 Dept 3115

*The Only
Mattress with
Push Button
Firmness
Control.*



FREE CATALOG
Huge Selection
Lowest Prices

America's Biggest Selection of Bargain Books

Overstocks, Remainders, Imports and Reprints from all major publishers. Books recently priced at \$20, \$30, \$40—now as low as \$1.95, \$2.95, \$3.95.

Thousands of titles, from yesterday's best sellers to books you never knew existed.

Over 40 subject areas: Science and Aviation, Biography, History, Literature, Politics, Sports, Fiction, Nature and more.

Fast Shipment, normally within 48 hours, and a moneyback guarantee.

Please send me your Free Catalog of Bargain Books.

Name _____

Address _____

City _____

State _____

Zip _____

HAMILTON

Box 15-405, Falls Village, CT 06031

HERITAGE AVIATION ART *Images from the Sky...*



THE BEST in aviation art by the world's most accomplished and well known aviation artists. We represent the finest in aviation art prints from *Aerodrome Press*, *The Greenwich Workshop*, *The Military Gallery*, and others.

TO ORDER OUR 56 PAGE FULL COLOR CATALOG send \$5, refundable with first purchase (U.S. Addresses) or \$10 (Outside U.S.) All purchases carefully packaged and guaranteed to arrive in perfect condition.

HERITAGE AVIATION ART
12819 S.E. 38th, Suite 211, Dept. AS
Bellevue, Washington 98006 U.S.A.
CALL 206/747-7429 or
1-800-331-9044



REVIEWS&PREVIEWS



victories and a translation of his valuable air combat operations manual.

After quickly sketching Richthofen's youth and early wartime service as Uhlan cavalryman and aerial observer, Kilduff concentrates on

Richthofen's career as ace and fighter leader. Personal insights based on contemporary sources enliven the book, which describes not only Richthofen's achievements and honors but also his glorification and his understanding of his role as a German hero. His leadership skills on the ground, as well as in the air, are manifest in his efforts to influence the definition of fighter units' duties and the procurement of airplanes for these units. Kilduff recounts the increasing toll of the war on Richthofen, how he was affected by a head wound and by deepening emotional depression, and ultimately, his death in combat at the zenith of his success.

This work, as its subtitle suggests, makes significant progress toward a more accurate and realistic account of Richthofen and his exploits. Yet it is not likely to be the last word on Richthofen. As Kilduff himself notes, sources in Russian hands may yield a wealth of information and enable even more definitive studies. Until that time, Kilduff's work will reign as the latest word on the Red Baron.

—John H. Morrow Jr. is Franklin Professor of History and associate dean at the University of Georgia and author of *The Great War in the Air: Military Aviation from 1909 to 1921* (Smithsonian Institution Press, 1993).

Saint-Exupéry: A Biography by Stacy Schiff. Knopf, 1994. 544 pp., b&w photos, \$30.00 (hardcover).

Count Antoine de Saint-Exupéry was a pilot-author whose poetic prose captured for thousands of readers the ecstasy of being airborne in the early days of aviation. Stacy Schiff's biography is an extensively researched life of the man who wrote four best-selling novels (*Wind, Sand and Stars*; *Night Flight*; *Southern Mail*; and *Flight to Arras*) yet is best remembered for a children's book, *The Little Prince*, which Schiff interprets as an expression of Saint-Exupéry's lifelong desire to escape a mundane adult society.

FIGHTER PILOT FOR A DAY

YOU FLY AIR COMBAT!
No Flight Experience Required!

- ★ FLIGHT GEAR
- ★ BRIEFING
- ★ FORMATION FLYING
- ★ AERIAL DOGFIGHTS
- ★ VIDEOTAPE OF FLIGHT

\$695⁰⁰

This is NOT a Simulator
FLIGHTS AVAILABLE
AT AN AIRPORT NEAR YOU!

WORLD FAMOUS

AIR COMBAT U.S.A., INC.

VISA **(800) 522-7590** **MasterCard**

NEW!

Military Dynamics, Inc.
proudly presents its

GREAT W. WAR II FIGHTER & ATTACK PLANE COLLECTION

A Collector's or Military Enthusiast's Dream!

- ▶ 30 Famous Planes From 7 Countries
- ▶ Ready-made Display Models
- ▶ Finely Detailed in 1:72 Scale
- ▶ In Solid Plastic
- ▶ Authentically Painted and Decaled*

*Also available unpainted

A Top Quality, Made In The USA Product

Send for free catalog to:
Military Dynamics, Inc.,
P.O. Box 9040-142, Mission Viejo, CA 92692,
or call 1-800-356-3600 (USA).

While Schiff's biography suffers from excessive detail, this story of a malcontent who was a better writer than he was a pilot, and who was happier in the air than on land, deserves a place on every reference library shelf.

—Doris L. Rich is the author of *Queen Bess: Daredevil Aviator* (Smithsonian Institution Press, 1993).

CURATOR'S CHOICE

Exploring the Sun: Solar Science Since Galileo by *Karl Hufbauer*.
Johns Hopkins University Press, 1991.
 392 pp., b&w photos, \$50.00
 (hardcover), \$19.95 (softcover).

Historian Karl Hufbauer has succeeded in showing how the use of rockets, satellites, and space probes to study the sun grew out of the centuries-old tradition of solar observation. He illuminates present knowledge about the nature of our star and its influence on Earth, and shows how the search for that knowledge has changed over the centuries. *Exploring the Sun* is the most comprehensive history of solar studies to date.

—David DeVorkin is a curator in the space history department of the National Air and Space Museum.



SOARS TO 600 FT.

3 PLANES IN ONE!



**FREE-FLIGHT
ROCKET GLIDER**



R/C ROCKET



R/C GLOW POWERED

New From HobbyLab!

FLY THE SR-71 BLACKBIRD

RIGHT OUT OF THE BOX!

**ORDER YOUR COMPLETE,
READY-TO-FLY MODEL TODAY!**

SPECS: LENGTH:..... 35.5"
 WING SPAN:..... 22.0"
 GROSS WEIGHT
 (TAKE-OFF):..... 14 OZ.
 FLYING WEIGHT:..... 8.5 OZ.

Recreated for your flying pleasure! The Super Secret SR-71 Blackbird, America's most advanced reconnaissance aircraft. Here is the first truly ready-to-fly replica right out of the box. Everything is included for your first flight! Insert the stabilizer, make a few adjustments, push the launch button and you blast off!

Pre-assembled and finished in Stealth Black "radar-absorbent paint", with a durable impact-resistant finish. Ready to fly as a Pre-Programmable Free Flight Glider. From your desk to 600 feet, in 2.9 seconds. At 600 feet, it becomes a glider that flies for up to four minutes Convert your SR-71 to a Rocket-Powered R/C Glider, using a low-cost R/C Conversion Kit. Want ultimate speed? Send for the Glow-Powered R/C Conversion Kit, with an optional Cox Black Widow .049 engine and R/C radio.

Order information for much more included in box.

INDICATE METHOD OF PAYMENT:

☐ Check ☐ Money Order payable to: HOBBYLAB

☐ Visa ☐ MasterCard. ☐ Am Exp.

Mail to: JAMI, 2 Blue Hill Plaza, Pearl River, NY 10965

Acct. # _____

Exp. Date ____/____/____ Sig.(x) _____

Name: _____

Address _____

City _____

State _____ Zip _____

TOLL-FREE ORDER LINE: 1-800-462-9522
 (1-800-HOBYLAB)

★ ★

HANDCRAFTED AVIATION DISPLAY MODELS

Over 300 Aviation Display Models Available

SHOWCASE MODEL CO.
P.O. Box 470, Dept. A/S-94-10
State College, PA 16804-0470

(800) 441-9524 - Orders
(814) 238-8571 - Catalogs
(814) 238-8572 - FAX



Boeing B-314 Pan American
"Dixie Clipper" (1/100th)
@ \$119.95 + 7.50 S/H









WORLD'S LARGEST MAKER OF AEROSPACE REPLICAS

★ ★



AIR CORPS

330 Aviation Street
Shafter, CA 93263

CLASSICS

ORDER NOW
(805) 391-9620

Allow 4 weeks for delivery Add \$5.00 shipping and handling (U.S.)

FROM **Twelve O' Clock High** TM

INTRODUCING

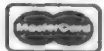

"One of the most sought after movie memorabilia items of all time"

The **918th** **TOBY MUG**
Bomb Group's

- ➡ Full size, accurate replica of original movie prop
- ➡ Officially licensed by Twentieth Century Fox Film Corp
- ➡ High quality, hand painted ceramic, made in the U.S.A

The first 500 units were numbered and packaged in sequence. Some of these special numbered editions are still available on a "first come, first served" basis. Order high or low numbers, a bomb group or squadron number, aircraft number etc.

ALSO AVAILABLE: 8" X 10" B & W Toby Mug studio stills \$5.95 ea./ \$9.95 both

<p>\$69.95</p> <p>\$49.95</p>	<p><i>"First 500 Series"</i> NUMBERED COLLECTOR EDITIONS</p> <p>STANDARD UNNUMBERED COLLECTOR EDITIONS</p>	 
---	--	---

CA residents add 7.25% TM 1949 Twentieth Century Fox Film Corp



FAMOUS AIRCRAFT OF WWII

14 Magnificent Photographs by Philip Makanna. In Full Color. Suitable for Framing. Each Page 20" x 14". Fold Out 20" x 28". Includes Aircraft Specifications and Silhouettes.

\$14.95 Plus \$4.00 Shipping/Handling
California Residents add 8.5% Tax

Foreign Orders in US DOLLARS ONLY. Foreign Surface Mail
Add \$5.00 Foreign Air Mail: ADD POSTAGE FOR 3 LBS

CALL TOLL FREE 800-331-8231

MasterCard/VISA Accepted

Corporate Discount Available

Or Send Check/Money Order or MasterCard/VISA to

GHOSTS, 665A Arkansas St., San Francisco, CA 94107

Fly a MiG in Moscow



BREAK THE SOUND BARRIER

in a MiG-21. Climb to the edge of space in a MiG-25. Experience a full-afterburner vertical takeoff in the MiG-29. Or, if you dare, attempt the legendary Cobra in the Su-27!

MIGS etc., in conjunction with the Russian aerospace industry, challenges you to climb inside the cockpit of a top Russian fighter. You need not be a pilot. Accompanied by a top Russian test pilot you'll take off from a top-secret military base and perform the same maneuvers wowing crowds at airshows.

MIGS etc. offers a variety of planes and flight packages. Supersonic packages start at \$5500. Call for a free brochure.

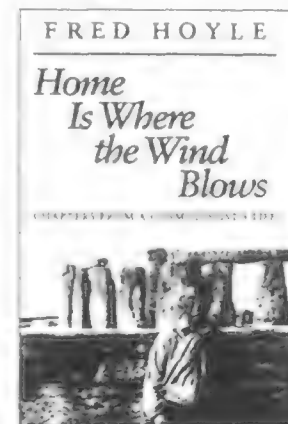
MIGS

MIGS etc., Inc.
800 MIGS ETC (USA)
813 923-0607
813 923-8815 fax

REVIEWS&PREVIEWS

Home Is Where the Wind Blows: Chapters from a Cosmologist's Life by Fred Hoyle. University Science Books, 1994. 443 pp., b&w photos, \$32.50 (hardcover).

Sir Fred Hoyle's autobiography offers insight into a remarkable character with a stunningly creative mind, albeit one that insists to the point of obsession on looking at every problem from a new angle. His often amusing saga carries us from an inauspicious beginning in the depths of Yorkshire, where he spent more time skipping school than attending it, to the years when he applied his great intellect to the challenge of getting into



Cambridge University. There he became famous for his insights into the formation of the elements in stars. Later, as a cosmologist, Hoyle invented the steady-state theory, which postulates that new matter is continu-

ously being created in the universe.

But Hoyle was never satisfied. He continued to look at problems from new angles and was always there to remind colleagues that perhaps not all was as well understood as they believed. To this day he insists that the Big Bang theory is wrong. His critics now tend to ignore him, which is a shame but part of the politics of science.

Home Is Where the Wind Blows tells what it is like for an intellectual non-conformist like Hoyle to survive in the highest echelons of research and administration, and what it is like when he finally leaves the mainstream, a place where he never really seemed comfortable. By thinking and living creatively, Hoyle was often misunderstood by his colleagues, and for that he paid a price. Some say his attitude cost him a Nobel prize for his work on the origin of the elements.

The few chapters in which Hoyle waxes technical will challenge lay readers but should not distract from this fascinating tale of intellectual courage, one that will give joy and inspiration to those similarly torn by the desire to be creative in a world where raw intellectual ability is regarded with suspicion.

—Gerrit Verschuur is a research professor in astrophysics at Rhodes College in Memphis, Tennessee, and is a contributing editor to *Air & Space/Smithsonian*.

RUSSIAN AVIATION

- As you've never seen it before



Three VHS videos show the past and present of Russian Aviation.

(1) *The Soviet Airforce Museum at MONINO* - the complete video tour. Over 100 fighters, bombers, commercial, and experimental aircraft depict the history of Soviet Aviation. (62 minutes)

(2) *Russian Aviation Museums - Part 2*. The remaining significant aviation museums in the former Soviet Union. A vast array of aircraft, armor, missiles, Francis Gary Powers U-2, Star City, and much more. (72 minutes)

(3) *Report from ZHUKOVSKY*. Highlights of the 1992 and 1993 Mosacroschows at Russia's largest flight test center. The ultimate Russian aviation flying video. (86 minutes)

Unique in concept and coverage, these videos belong in the library of every aviation historian and enthusiast.

One Video \$39.50,
additional videos are \$25 each when ordered
with first video.

Prices postpaid to the USA and Canada.

Overseas airmail:

Europe and Latin America add \$4 for

Asia, Africa and Pacific, add \$6 for

JET-AGE PRODUCTIONS

P.O. Box 2509

Silverthorne, Colorado 80498 USA

WWII ID Recognition Models

Free Brochure

Exact museum quality replicas of World War II 1/72 scale black plastic originals as displayed in aviation museums worldwide

Classic Aircraft Collections, LTD.

800-289-3167

FAX 817-927-1889

3321 Suffolk Ct. W. Suite 105
Fort Worth, TX 76133-1151

STAR TREK

THE NEXT GENERATION

U.S.S. ENTERPRISE™ NCC-1701-D

Limited edition, hand crafted, fine-scale-brass museum standard model, 2'3" long. Authentic colors, internal lighting with all surface detailing and flashing lights.

\$1,980.00 + S&H. Approved and licensed by Paramount Pictures
Voice 1-800-307-7447 • Fax 1-510-337-0771

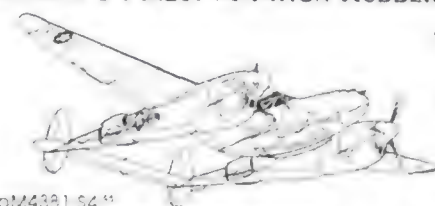
Masterpiece Replicas Inc.

1150 Marina Village Pky, Ste 103 Alameda, CA 94501 USA

TM, ® & © 1994 Paramount Pictures. All Rights Reserved

IMAGINAIR DESIGNS

WORLD'S FINEST AVIATION RUBBER STAMPS



PM4381 \$4.95

CATALOG
OF 400
DESIGNS
ONLY
\$2

1007 Woodland NW #5, Albuquerque, NM 87107 • 505/345-2308

AIR&SPACE

Offers Back Issues

1986-1987 Selected issues available.

December 1987/January 1988. Captain Midnight, Soviet polar flights, UFOs.

February/March 1988. Swedish air force, NASP head, wind tunnels, BASE jumping.

August/September 1988. Reef encounter, Piaggio, NASA photos, Air National Guard.

December 1988/January 1989. X-1 engine, mini-space station, Galileo, soaring.

February/March 1989. B-52, Scout rocket, baggage handling, space art.

June/July 1989. Special Apollo issue! "Apollo 11" poster, Saturn V, how we got to the moon.

August/September 1989. The C-5, LDEF, Pan Am's Pacific, Kansas space museum.

October/November 1989. Mars propulsion, World War II's black pilots, spacesuits.

December 1989/January 1990. Autogiro, Voyager 2, Antarctica, weightless life.

February/March 1990. The Japanese Zero, Salyut 7, Magellan, frequent flier's dream.

April/May 1990. Nuclear cruise missile, meteorites, Lindbergh, nose art.

June/July 1990. Battle of Britain I, life in Star City, satellite sleuths, solar-power satellites.

August/September 1990. Target drones, Battle of Britain II, spearing a comet.

December 1990/January 1991. Sound barrier, Cosmodrome, X-rays, collision avoidance.

February/March 1991. Blimp, life on Mars?, rivets, electronic warfare.

April/May 1991. Space shuttle poster, ultralights in Egypt, X-31, lifting bodies.

June/July 1991. Mars rovers, Jimmie Angel, P-51, beyond the shuttle.

October/November 1991. World War I fighters, asteroids, F-86 pilot, airmail.

December 1991/January 1992. Moonbase, spysats, cocaine wars, Biosphere II, models.

February/March 1992. Pararescue, Admiral Yamamoto, nuclear rockets, Skylab.

April/May 1992. Reno races, speed poster, Big Bang theory, satellite rescue, the Shack.

June/July 1992. Space camp, GPS, hot jets, lovely losers, German boatplanes.

August/September 1992. Blue Angels, extraterrestrials, Amelia Earhart, Willow Run.

October/November 1992. Russian skydiving, importing the jet, tabloid tales, SETI.

December 1992/January 1993. P-38 on ice, the Boeing 747, Mighty Eighth, baby stars.

February/March 1993. Spruce Goose, V-2, terrorism, Russian space, dark matter.

April/May 1993. Airshows, probes poster, Star Trek, flight attendants, sun's edge.

June/July 1993. Test pilots, underwater warplanes, NASA's big tank, Jane's, gamma rays.

August/September 1993. NASA's ER-2s, Big Guns, black holes, banners, orbital rendezvous.

October/November 1993. X-plane poster, startup airlines, Martin Mars, space monkey.

December 1993/January 1994. Flight from Cuba, Russian women pilots, death of Eastern.

February/March 1994. Aggressor squadrons, Delta Clipper, James Gordon Bennett Race.

April/May 1994. Skunk Works poster, designing the Boeing 777, a direct route to Mars.

June/July 1994. B-26 Marauder, solar sails, Wright re-creations, Apollo 11 memories.

August/September 1994. Spy missions over Russia, flight in the movies, Bessie Coleman, the von Braun team in America.

Cost: \$5.00 per issue (foreign: \$6.00). Allow 4-6 weeks for delivery.

Send orders to: Back Issues, *Air & Space/Smithsonian*, 901 D St. SW, 10th Fl., Wash., D.C. 20024

"Bravo! Benissimo!" George Harold Cronin was one of 600 American air cadets sent to Italy in 1917-18 for flight training. Cronin was later posted to an Italian bombing squadron on the Austrian front, flying Caproni bombers. Now 97, he lives in Falls Church, Virginia. In writing this reminiscence, he was assisted by Theodore Hamady and Charles Walthall, members of the League of World War One Aero Historians.

The Flipper Factor. In addition to getting a crash course in dolphins, James V. Shannon's adventures included possibly torpedoing a Soviet snoop submarine during an exercise, and launching the first ballistic missile (a Polaris from the AX series) to complete an outside loop during 20 years of naval weapons R&D at General Electric. His account of a failed Juno II launch appeared in the last issue.

Ozone Forecast: Partly Cloudy. Carl A. Posey is an occasional contributor to *Air & Space/Smithsonian*. He is currently working on a novel entitled *Senator's Will*, and his coffee-table book on the atmosphere, *Wind & Weather*, is due in November.

Back to the Basics. Bill Marsano, a travel writer living in Manhattan, wants his epitaph to read: "He looped a Stearman."

Bear Arms. Bill Sweetman has learned that many of his writings on international aerospace technology have been translated and analyzed by Russian intelligence agencies. His most recent book, *Aurora—The Pentagon's Secret Spyplane* (Motorbooks, 1993), must really have them wondering. In addition to books, he writes regularly for *Interavia* and *Popular Science*.

A Trip to the Moon. Frank H. Winter, curator of rocketry at the National Air and Space Museum's space history department, is interested in popular culture and the early history of spaceflight. Consultant and writer Randy Liebermann chairs the International Academy of Astronautics' subcommittee on arts and literature.

Life in the Egg. In addition to serving as a Minuteman crew commander, Michael R. Boldrick was a test director during development of the MX missile. He now works for SRI International (formerly the Stanford Research Institute) in Menlo Park, California.

NOW YOU CAN OWN THE PILOT COMMANDER CHRONOGRAPH EVEN IF YOU DON'T FLY AN F-16

Know the joy of owning this high tech professional masterpiece; dozens of functions with six hands, four dials, twin push buttons, rotating bezel, brushed and polished steel band, this self winding, water resistant attention-getter is a solid investment that promises to increase in value. Limited supply. Not available anywhere else. Money back guarantee. Lifetime warranty. A \$200 value NOW ONLY \$99.



Send payment to:
Flight Group One
270 N. Canon Dr. Dept 1402-A1, Beverly Hills, CA 90210
Credit card orders call toll free: 1-800 544-4365

YOUR FAVORITE AIRCRAFT...



CUSTOMIZED TO YOUR WISHES

- *Over 20,000 aircraft types available
- *Your choice of paint scheme, tail #, etc.
- *Handcarved from solid mahogany
- *Completely handpainted—no decals at all!
- *Scale variations from 5 inches to 5 feet
- *Engraving and logo on customized stand

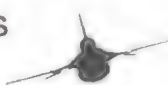
MC, Visa, AMEX, Discover

ANDERSON ENTERPRISES

405 Osage Drive
Derby, KS 67037
(Visit our store 5nm S of Wichita)

1-800-732-6875

Custom built replicas—2nd to none!



Cosmonaut Watch

Precise, 21-jewel Chronograph - \$249. Same model as worn by Yuri Gagarin. KGB Binoculars - \$49.95
MIG-29 Clock-\$399. FREE Shipping! FREE Brochure!
Major Credit Cards or send check/m.o. to Hall Int., Ste. 200-AS, 109 Northshore Dr., Knoxville, TN 37919, Fax (615) 588-0099

CALL NOW! 1-800-960-6009

KITES

FREE COLOR CATALOG

Choose from over 200 exciting kites.
• Many unusual & innovative designs.
Call or write for your catalog today!

Into The Wind • (800) 541-0314
1408-K Pearl St., Boulder, CO 80302



C-D *OLD* TIME *PLANS!

★ WORLD'S GREATEST TRUE SCALE PLANS VARIETY!
Since 1919 I am still making my world-famous historic Master flying model plans available to all. From 1/32 to 1/4 size (but 3/8" to 1" scale, full size) for R/C, C/L, F/F, rubber, elec., static. All types. There is nothing else like them anywhere—1400 plans! Real collector's choice items. Ask any old time modeler or see many of them in Air Force, Naval & D of C area Museums. Scale-like wood and fabric construction throughout. Illustrated price list \$1. bill, or with complete pictorial booklet only \$2. Outside USA (except Can. and Mex.) by air \$1. extra.
Edward T. Packard—Aviation's Best Friend
CLEVELAND MODEL & SUPPLY CO.
9800AS DETROIT AVE. Cleveland, Ohio 44102

CREDITS

The Cyberspace Program. Tony Reichhardt is a frequent contributor to *Air & Space/Smithsonian*. The father of a one-year-old, he'd like the option of exploring Mars from home.

Further reading: *Virtual Reality*, H. Rheingold, Simon & Schuster, 1991.

The Skies, the Limits. Eight years after

the birth of ICAO, Henry Scammell left Harvard College for a 15-month stint with Pan Am at Idlewild and never got over it. His piece on the 50th anniversary reenactment of the flight of the China Clipper appeared in *Air & Space/Smithsonian's* inaugural issue, followed by *Pan Am's Pacific* (Aug./Sept. 1989) and *Life After Eastern* (Dec. 1993/Jan. 1994).

A Cache of Canadian Classics. Gord Struthers is assistant city editor at the Saskatoon *Star Phoenix*.

CALENDAR

October 1 & 2

Experimental Aircraft Association Antique Classic Chapter 7 Fly-In. Sussex Airport, NJ, (201) 702-9719.

Open Cockpit Weekend. New England Air Museum, Bradley International Airport, Windsor Locks, CT, (203) 623-3305.

October 7-9

Aviation History Seminar and Tour. Sponsored by Oglethorpe University. National Air and Space Museum, Washington, DC, (404) 231-0547.

October 8 & 9

AIRSHO 94. Sponsored by the Confederate Air Force. Midland International Airport, between Midland and Odessa, TX, (915) 563-1000.

Florida State Air Fair. Kissimmee Municipal Airport, FL, (407) 846-4222.

October 15

Reunion of the 48th Fighter Squadron, 14th Fighter Group, 15th Air Force. Orlando, FL, (904) 246-9618.

October 15 & 16

Wings Over Houston Airshow. Sponsored by the Gulf Coast Wing and the West Houston Squadron of the American Airpower Heritage Museum. Thunderbirds, warbirds, aerobatic and vintage aircraft. Ellington Field, Houston, TX, (713) 784-5200.

October 29 & 30

Airshow Orlando. Thunderbirds, Sean D. Tucker, and the Red Baron Stearman Squadron. Central Florida Regional Airport, Sanford, FL, (407) 846-4222.

November 5 & 6

Wings of Warmth Fly-In. Sponsored by

the Mid Atlantic Air Museum. The Salvation Army will collect donations of nonperishable food, clothing, and new, unwrapped toys. Reading Regional Airport, PA, (610) 372-7333.

November 6

New England Air Museum Behind-the-Scenes Tour. Guided tours of the aircraft restoration facility. Bradley International Airport, Windsor Locks, CT, (203) 623-3305.

November 9 & 10

Russian Aviation/Aerospace Executive Symposium. Arlington Renaissance Hotel, Arlington, VA, (703) 451-2175.

November 9-13

Aviation History Seminar and Tour. Sponsored by Oglethorpe University. National Museum of Naval Aviation, Pensacola, FL, (404) 231-0547.

November 12 & 13

Flying Days. Lone Star Flight Museum, Galveston, TX, (409) 762-3930.

Plastic Scale Model Show. New England Air Museum, Bradley International Airport, Windsor Locks, CT, (203) 623-3305.



"Let's swing back by Earth.
It's been ages since we colonized it."

"The Satellite Sky" Update/44

These regular updates to "The Satellite Sky" chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches

90 to 300 MILES

	Soyuz TM-19 7-1-94 TT
	Cosmos 2283 7-20-94 PL
	Cosmos 2284 7-29-94 TT

300 to 630 MILES

	Nadezhda 4 7-14-94 PL
	Cosmos 2285 8-2-94 PL

630 to 1,250 MILES

	APEX 8-3-94 Pegasus
--	-------------------------------

Inoperative but still in orbit










630 to 1,250 MILES

Cosmos 2211-16
Tubsat

21,750 to 22,370 MILES

Galaxy 2

21,750 to 22,370 MILES

	Intelsat 7B 6-17-94 KOU
	Fleetsatcom UHF 6-24-94 CAC
	Cosmos 2282 7-6-94 TT
	PanAmSat 7-8-94 KOU
	BS-3N 7-8-94 KOU
	Apstar-1 7-21-94 XI
	DBS-2 8-3-94 CAC
	Brazilsat B-1 8-10-94 KOU
	Turksat 1B 8-10-94 KOU

Deletions

90 to 300 MILES

Cosmos 2274
down 5-21-94

Cosmos 2281
down 6-29-94

Progress M-22
down 5-23-94

Progress M-23
down 7-2-94

Launched but not in orbit

90 to 300 MILES

Foton 6 research	6-14-94	down 7-2-94
STS-65 research	7-8-94	down 7-23-94

DATA: SAUNDERS KRAMER

FORECAST

In the Wings...

Ain't Nothin' Like the Real Thing. The Walter Mittys among us who have dreamed of piloting legendary airplanes can now wake up and smell the kerosene. Companies offering the chance to fly the classic P-51 Mustang or today's hottest MiGs are finding plenty of takers for these not-so-cheap thrills.

Sunset on Pulkovo. Once a premier astronomical center, Russia's Pulkovo Observatory has triumphed over revolutions, wars, and purges but may not survive the new capitalism.

Zero G at Zero Altitude. Scientists who

can't get their microgravity experiments on the always-overbooked space shuttle can just send their payloads down the tube—the 430-foot tube at the NASA Lewis Zero Gravity Research Facility.

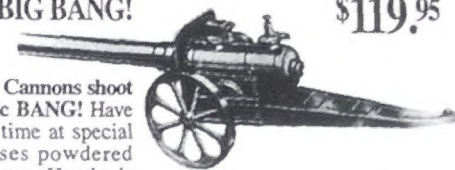
Sub Hunt. The hunter is a loud, worn P-3C turboprop with a 12-man crew as distant from cold war fears as they are from home. The quarry is a lone submarine somewhere beneath the ice in a 200- by 300-mile rectangle near the top of the world.

Souvenirs, Sundries, and Sandwiches in Space. The crazy assortment of collectibles that have gone into orbit and beyond would do any general store proud.

Celebrate July 4th & All Events CARBIDE CANNON

BIG BANG!

\$119.95



Mammoth Cannons shoot with terrific BANG! Have a bang-up time at special events. Uses powdered carbide ammo. Hundreds of shots for few cents. All metal construction with large, rugged cast-iron wheels. Machined brass mechanism for easy loading and firing. Authentic turn-of-century design. Handsome decor when not in use. Made in USA to last a lifetime. Available in 3 sizes: 9" cannon, \$49.95 postpaid; 17" cannon, \$89.95 postpaid; 25" cannon (shown here) with rapid firing and automatic loading, \$119.95 postpaid. The larger the cannon the louder the bang! Carbide ammo, about 100 shots, \$6.00; 3 packs for \$15.00. Send check, money order or call. Visa, MasterCard accepted by mail or phone (610) 866-0777. Give card number & expiration. Money-back guarantee.

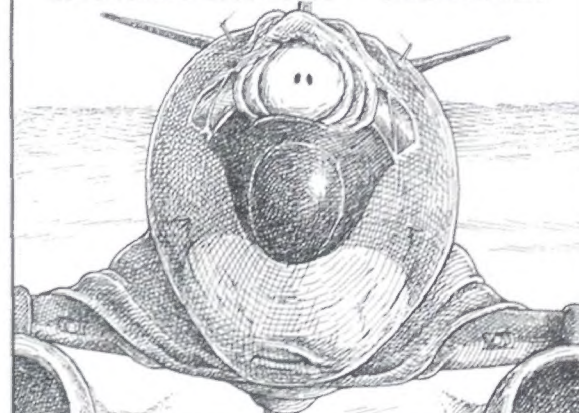
The Conestoga Co., Inc., Dept A, PO Box 405, Bethlehem, PA 18016

☐ SEND FOR FREE CATALOG ☐

WHICH AVIATION COLLEGE FOR YOU?

Over 300 colleges offer aviation related programs. We can assist you in making this most important decision. For free details send name and address to: Aviation Education Consultants, 47578 Coldspring Place, Suite 700, Sterling, VA 20165.

HANK CARUSO'S 1995 AEROCATURES™ CALENDAR



The 1995 Aerocatures™ Calendar features: Apollo Lunar Lander, RF-101 Voodoo, E-6A Tacamo, TH-57, KC-135 & F/A-18, Coast Guard HH-3F, F-100 Super Sabre, B-26 Marauder, Straight deck carrier ops, V-22 Osprey flight test, F-111 Aardvark, Marine rotary wing family portrait. Actual calendar size is 8.5" x 11". Apollo Lunar Lander cover illustration in full color. Two bonuscolor Aerocatures™ suitable for framing are included: F4F Wildcat & C-130 Hercules.

Cost is \$12 per calendar + \$3 SHIPPING & HANDLING (U.S. and Canada) per order. Maryland residents add 5% SALES TAX. Fees for shipping fees outside U.S. and Canada, quantity discounts (25 or more), and wholesale orders on request. Not responsible for shipping damage. Sorry, no cash, CODs, or credit cards. Non-U.S. orders: money orders only in U.S. dollars redeemable through U.S. agent.

ForeFeathers™ Enterprises
7814 Solari Court, Dept. AS
Pasadena, MD 21122 USA

A-OK! THE WINGS OF MERCURY

The year is 1962...

The place is Cape Canaveral, Florida...

"All systems are A-OK!"

- An ultra-realistic simulation of America's first manned spacecraft, Project Mercury!
- Based on the original NASA specifications!
- Reproduces all switches, gauges & systems!
- Full color, digital sound, including CapCom!
- Actual NASA checklists & flight plans online!
- Macintosh only. Color, 5.5 Meg free RAM, QuickTime 1.6, System 7 required.
- \$79.95+3.95 S&H Visa/MasterCard

For information/orders, call: 1-800-9 SPACE 4 with name, address, card # & exp date or write to:

Do you have the right stuff to fly the real thing?
INNOVATIVE! 156 Seventeenth Avenue
TECHNOLOGIES! Brick, N.J. 08724-1814





A Cache of Canadian Classics

During the second world war, formations of brightly painted Avro Ansons, North American Harvards, and Cessna Cranes constantly droned over the wooded foothills and jagged mountain peaks around Calgary. Far from the fighting in Europe, Canada's vast open spaces offered an ideal site for training airmen, so when Britain saw that war was inevitable, it formulated the British Commonwealth Air Training Plan, which brought men from around the world to small Canadian towns like Brandon, Moose Jaw, Saskatoon, and Medicine Hat to earn their wings. By war's end, more than 130,000 pilots, navigators, bombardiers, gunners, and flight engineers had been trained in Canada to serve in the Allied air forces.

The plan's western command was headquartered in Calgary, but today there are few signs of the massive undertaking left in the city. One remnant of the period is a drill hall where freshly minted pilots of the No. 37 Service Flying Training School were awarded their wings. Today the building is home to the Aero Space Museum of Calgary, an operation struggling to preserve western Canada's aviation heritage.

The large, spartan building is crowded with engines and aircraft in various stages of restoration, including several of the trainers that flew in the area during the war. Restorers have found parts for the trainers scattered around the farmyards surrounding the sites of the old training bases. Some farmers had tried to jury-rig the equipment into their farm machinery—using a wing as a land leveler, for example.

The museum's displays also include ultralights, home-builts, and combat aircraft. On a recent visit, a group of schoolchildren, delighted with the haphazard exhibits, swarmed around an odd-looking de Havilland FB3 Vampire jet, running under its double-boom tail and climbing a stepladder to get a peek inside the cockpit.

The partially assembled aircraft offer fascinating cutaway views rarely found

outside of technical manuals. A wingless Hawker Hurricane awaits its turn in the restoration shop, its 12-cylinder Rolls-Royce powerplant sitting beside it on the floor. Next in line is a rare Barkley-Grow T8P-1 that seems a paint job away from resuming its tasks in the opening of

Aero Space Museum of Calgary, 64 McTavish Pl. NE, Calgary, Alberta, Canada T2E 7H1. Phone (403) 250-3752. Open Mon. to Fri., 10 a.m. to 5 p.m.; weekends and holidays, noon to 5 p.m. Admission: up to \$5, depending on age.

Canada's north. The museum also plans to refurbish a hulking Lancaster bomber and a Fairey Swordfish—a fabric-covered biplane used in the early days of World War II as a torpedo bomber.

The most striking artifact is a World War I Sopwith Triplane fighter. Though it is made up primarily of new parts, it does include some original components: a Clerget 9B rotary engine, an engine cowling, and turnbuckles—devices for tightening flying wire.

The Triplane project was initiated by the late Stan Green, a former aircraft engineering instructor who had found the engine in pristine condition in a farmyard near Edmonton. Inspired by his find, Green eventually approached the museum and got its support for construction of a Triplane. He obtained an original plan for the airplane from British Aerospace, which had taken over the Sopwith Aircraft Company after the first world war, and set out on a quest for components. The search spanned two continents and extended through networks of museums, collectors, and some of the original subcontractors that had supplied Sopwith. The museum procured the cowling from a collector in England by swapping a Spitfire propeller hub with him. The turnbuckles were found among the wares of a military surplus dealer in Pasadena, California. Other materials and services were

donated by local businesses.

Twenty years after construction began, the craft is nearly complete except for its covering. It will be finished in the distinctive livery of the all-Canadian Black Flight unit (the Royal Naval Air Services' No. 10-B Squadron). Before the airplane flies, the Museum plans to ask British Aerospace to assign it the next serial number from the original Sopwith production run.

The Triplane is only one of the museum's major restoration projects. A 1946 Noorduyt Norseman Mk.V, one of the first aircraft tailor-made for pilots operating in the Canadian bush, now hangs in the atrium of one of the office towers studding downtown Calgary. A Supermarine Seafire Mk.XV is on display at the Naval Museum of Alberta across town, and in front of the hall are six restored aircraft: a DC-3, two Sikorsky helicopters, a CF-100 Canuck, a CF-101B Voodoo, and a Beech 18.

Curator Jacek Malec has some big ambitions for the museum—bigger, for now, than the museum's budget. Behind a canvas curtain that separates the restoration shops and a small library from the display areas, the parts of a de Havilland PR 35 Mosquito lie in a heap reaching almost to the ceiling. Where an untrained eye would see a pile of scrap, Malec sees "F for Freddie," a bomber brought to Canada to promote victory bonds after completing 213 missions over occupied Europe—more than any other Allied bomber in World War II. "F for Freddie" (the nickname is based on the aircraft's squadron designation, GB-F) arrived in Calgary less than 24 hours after VE Day, greeting residents with a heart-stopping, low-level flying demonstration over downtown. The next day, while buzzing the city's airport at nearly 400 mph, the airplane struck a control tower and crashed, killing two highly decorated war heroes.

"It's another one of those little stories that we want to keep alive," says Malec. "That's what we're doing here."

—Gord Struthers



**We've been known to send some people's garbage
right back to their house.**

It may come back to light a room, cook your food, or even heat your home. Because all that garbage you threw out actually had a lot of energy in it.

Energy that, once the garbage is in a landfill, is released as methane. Methane is just like natural gas. It's a clean-burning fuel. Good enough to fuel turbines that run power generators. Like the 4,000-kilowatt generators that supply 13,000 people in Geneva, Illinois with electricity. All from the local landfill. Or the generators at the 29 other sites around the country where we capture methane to generate power.

Last year alone, we produced enough energy from methane to save 1.9 million barrels of oil. Not only as electricity, but also as an alternative fuel to actually replace gas, oil, or coal for industry. In 1993, we sold it to customers like a carmaker and a chemical company. All of which makes good use of landfill gas.

It comes from garbage, but it's nice to know it's not going to waste.

What business do we have saying we help the environment? That is our business.



Waste Management
A WMX Technologies Company



"If you want to grow old as a pilot, you've got to know when to push it, and when to back off." *Chuck Yeager*

Throughout his remarkable career, Chuck Yeager has shown an uncanny talent for what pilots call "pushing the edge of the envelope." At 21, only three years after boarding his first plane, Yeager was leading a squadron of fighter pilots in World War II. And at the age of 24, he became the first person to fly faster than the speed of sound.

Attempting such dangerous feats is one thing. Living to describe them to your grandchildren is another. Displaying the enormous courage, skill and cool judgment needed to do both has made General Chuck Yeager an authentic American hero.


Although retired from the military, Yeager remains a man on the move. He's an avid sportsman with a lifelong

love of the outdoors, a lecturer and a consulting test pilot who still loves to fly. "Maybe I don't jump off 15-foot fences anymore," said Yeager, "but I can still pull 8 or 9 G's in a high-performance aircraft." And in all his exploits, Yeager depends on a rugged and reliable time-piece. "I wore a Rolex 40 years ago when I broke the sound barrier and I still do today," says Yeager matter-of-factly. "A pilot has to believe in his equipment. That's why I wear a Rolex."



ROLEX



Rolex Oyster Perpetual GMT-Master II Date Chronometer in stainless steel and 18kt gold with matching Jubilee bracelet. Write for brochure. Rolex Watch U.S.A., Inc., Dept. 406 Rolex Building, 665 Fifth Avenue, New York, N.Y. 10022-5383. Rolex, , Oyster Perpetual, GMT-Master II and Jubilee are trademarks.